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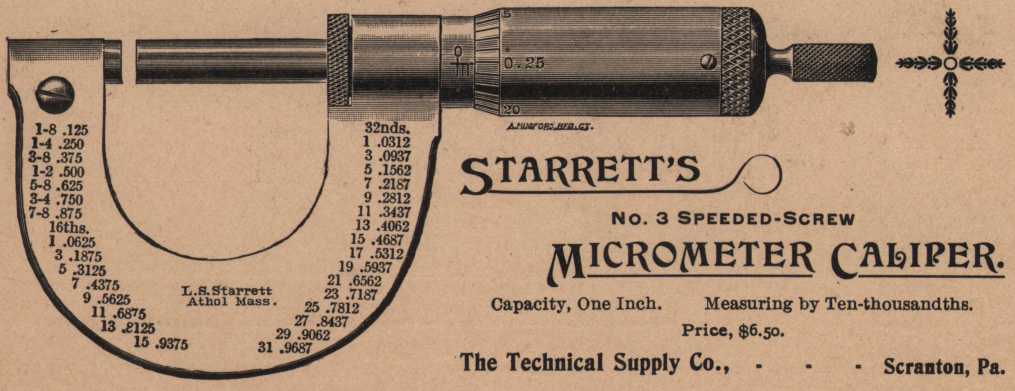

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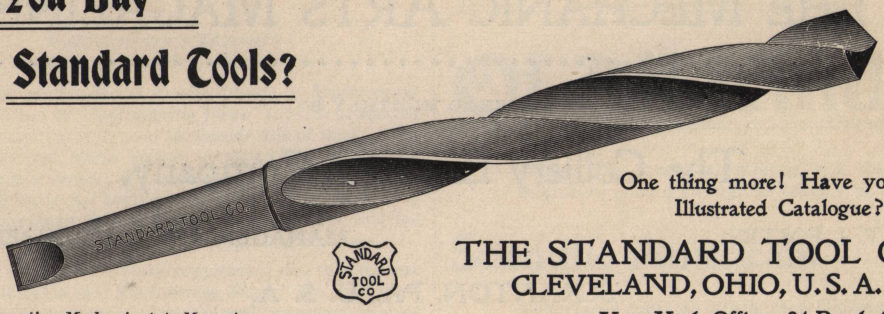

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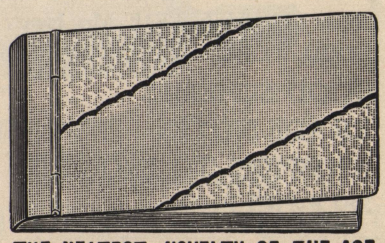

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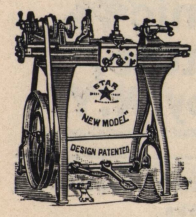

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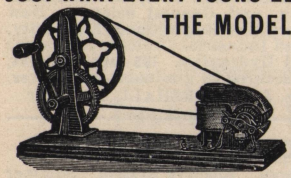

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THE MECHANIC ARTS MAGAZINE.

Vol. IV. JUNE, 1899. No. 5.

THE TESTING OF STEEL.

(*Continued from the May, 1899, Number.*)

C. P. Turner.

THE STRESS-STRAIN DIAGRAM—SIGNIFICANCE OF THE RESULTS OBSERVED—VALUE OF THE COLD-BENDING TEST—EXAMPLES OF BROKEN AND BENT TEST SPECIMENS.

AFTER a specimen has been broken as described, and the broken pieces are placed with the fractured ends together, it is found that the marks made on the original bar are farther apart than before the test, showing that the steel has stretched before breaking. With very hard steel the amount of stretch is comparatively small, although there is always a measurable change in the length of even the hardest and most brittle steel. The softest steels stretch a great deal; the length generally used as a standard from which the stretch is calculated is 8 inches, and with the best grades of soft boiler plate or rivet steel an elongation of 2 inches, or 25 per cent. of the original length of 8 inches, is common, while more than 30 per cent. is sometimes obtained.

The relation between the pull, or *stress*, on the specimen and the corresponding change in length, which engineers now generally call *strain*, or *deformation*, is best shown by means of what is called a *stress-strain diagram*. Fig. 4 is such a diagram for a specimen of soft machinery steel. On this diagram the vertical distance from the horizontal line $o\,x$ of any point on the irregular line $o\,a\,b\,c\,d$ represents the stress, in pounds per square inch of sectional area, on the specimen, while the corresponding strain is represented by the horizontal distance of the same point from the vertical line $o\,y$. Each of the small spaces above the line $o\,x$ represents a stress of 1,000 pounds per square inch, while each similar space from the line $o\,y$ towards the left represents an elongation of the specimen of 0.01 inch, the original length in this case being 6 inches.

An inspection of the diagram shows that the elongation, when the stress has reached 40,000 pounds per square inch, is less than $\frac{1}{100}$ inch, and that up to this point the elongation increased in almost exact proportion to the increase in the load. Above the point a, corresponding to the stress of 40,000 pounds per square inch, the elongation increased more rapidly than the increase in the load, as is indicated by the curve from a to b. At b, when the stress has reached an intensity of about 43,300 pounds per square inch and the specimen has stretched about $\frac{1}{50}$ inch, there is a sudden change; the specimen stretches rapidly with almost no increase in the stress until the point c is passed, after which the load increases slowly again until the maximum, about 63,000 pounds per square inch, with a total elongation of 1.96 inches, or nearly 33 per cent. of the original length of 6 inches, is reached. In order to show the diagram on as large a scale as possible, the part beyond the 1.10-inch mark, which represents that part of the test during which the area of the specimen decreased before the break occurred, is omitted.

We will now consider the significance of the different features of the test, as shown by the diagram. From o to a we have seen that the strain is almost exactly proportional to the stress; that is, between these points the increase in the length of the specimen for each increase in the load of, say, 1,000

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pounds, is always nearly the same. Further, if a load less than the 40,000 pounds had been applied and then removed, it would have been found that the specimen returned to its original length; such a load would have produced no perceptible set, or permanent change in the length of the specimen, a condition which we express by saying that, within certain limits, the steel is perfectly elastic. The limiting stress below which there is no apparent permanent change in the length of our specimen, is called the *elastic limit;* theoretically, the material will safely carry any load within this limit. If the elastic limit is not exceeded, the material, after a load is removed, will return to its original form no matter how often such a load is applied and removed.

In consideration of the constant proportion which it is assumed exists between the stress and strain, the very expressive term, *limit of proportionality*, has been applied to the limit below which each increase of a certain amount in the load produces the same change in the length of the specimen. Although this limit, which for steel generally agrees very nearly with the elastic limit, is seldom considered by American engineers and writers of textbooks on the mechanics of materials, a factor that is much used in calculations pertaining to the deflection of beams and springs is based on the theory of the proportionality of stresses and strains; this factor, called the *coefficient*, or *modulus, of elasticity*, is the result obtained by dividing the stress on each unit of area of the section of a specimen by the resultant strain in each unit of its length. The English unit of stress generally employed for this purpose is the pound per square inch; using this unit, the coefficient of elasticity is the quotient obtained by dividing the product of the original length on which the elongation is measured and the total stress in pounds by the sectional area of the specimen in square inches multiplied by the total elongation in inches. The coefficient of elasticity may also be defined as the load in pounds that would stretch a specimen having a sectional area of one square inch to twice its original length, assuming the limit of proportionality to be sufficiently high to permit of this deformation under a constant ratio of stress to strain.

It is interesting to note that the coefficient of elasticity for all grades of steel is practically the same, about 29,000,000. The very delicate measurements involved in its determination leave the exact value somewhat in doubt, different observers having obtained values differing considerably from the coefficient here given.

We have seen that, within the elastic limit, as shown by the diagram, the total elongation of the 6-inch specimen is less than $\frac{1}{100}$ inch, and that this change in length requires the application of a stress of 40,000 pounds per square inch. The diagram also shows that, for the first increase of 3,000 pounds in the intensity of the stress beyond the elastic limit, the rate of elongation increases quite slowly, the total elongation, under a stress of 43,000 pounds, being less than $\frac{1}{50}$ inch. These small changes in length can be accurately measured only by the use of measuring devices of considerable delicacy, and much care must be exercised in order to determine the stress under which the rate of elongation begins to change. A number of very ingenious instruments have been devised, which, used in connection with the testing machines shown in Figs. 1 and 2, automatically trace a diagram similar to Fig. 4. These autographic devices, while very valuable for certain classes of testing, are rather delicate, and require considerable care and skill in their use; in order to produce reliable diagrams, they must be carefully attached to the specimen and accurately adjusted, and this takes more time than is generally available when a large number of tests must be made.

Our diagram shows that from o to a the line, even when its scale is multiplied five times, does not vary from a straight line by an amount that can be detected; however, by measuring the changes in the length of specimen with micrometer calipers measuring to $\frac{1}{10000}$ inch, it is found that the point where the line begins to curve is considerably below the point where such curvature is perceptible on the diagram; in other words, the true elastic limit is not at the point indicated by a, but at some point considerably below it. It is, in fact, altogether probable that, if we were able to make measurements sufficiently small, it would be found that steel is not perfectly elastic under even the least stress, and that any load, however small, produces some permanent set. For all practical purposes, however, we are justified in saying that there is a limit within which the recovery of its original form is complete, no matter how often the stress is repeated.

Various arbitrary rules have been proposed for locating the true elastic limit on a diagram similar to that shown in Fig. 4;

these methods, however, serve merely to locate a point on the curve which establishes, with a moderate degree of uniformity, a stress that bears a certain relation to the elastic properties of the material, but they do not definitely locate the true elastic limit, and, in the opinion of the writer, they are of comparatively little practical value in determining the properties of the specimen and its value as a material for constructive purposes.

There is, however, one feature of our diagram which marks a perfectly definite stage in the effect of the stress on the specimen, and one that is readily determined in ordinary testing, without the use of delicate instruments or much loss of time. From *b* to *c* the diagram shows that in the length

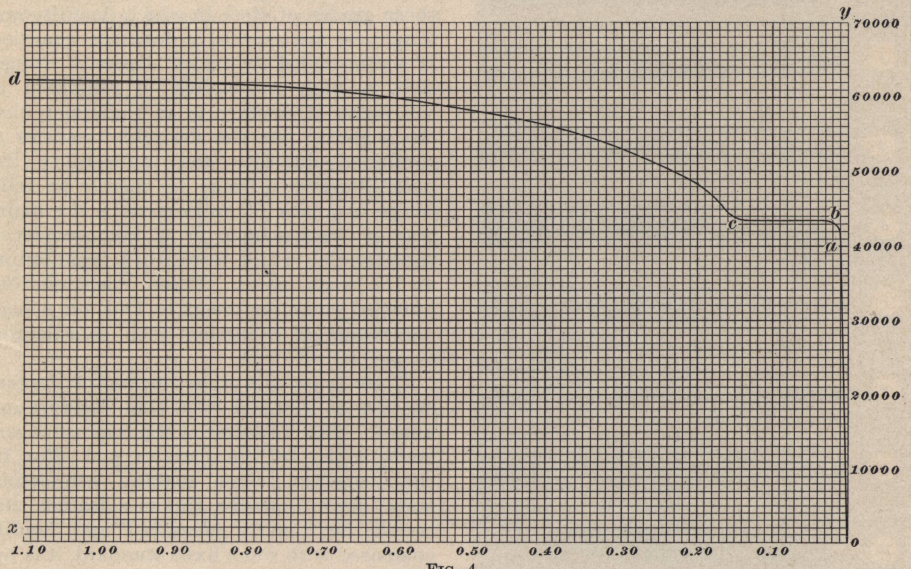


FIG. 4.

of 6 inches the specimen elongated about .12 inch, or nearly $\frac{1}{8}$ inch, with very little change in the stress. A little practice enables the operator to detect this period in the test without the use of any special instruments, particularly with all but the hardest grades of steel. As the stress is applied to the specimen, it is found that up to this point the poise must be steadily moved out on the beam of the weighing scale, but, when this point is reached, the beam remains stationary, with no change of the poise during a very perceptible lengthening of the specimen under the action of the stress. Also, if it has not been previously removed by machining, when this point in the test is reached, the scale formed on the specimen during the process of forging or rolling suddenly begins to loosen and fall off.

As previously explained, the point at which the specimen suddenly elongates, without an increase in the stress, is scientifically known as the *yield point*, while in practical commercial testing it is commonly called the *elastic limit*. In much the greater number of reports of tests on specimens that are sent out from the rolling mills, the value quoted as the elastic limit is really the yield point as determined by the simple methods described above. Although this point is not scientifically as correct a gauge of the properties of the material as the theoretically true elastic limit, it is, on account of the ease and certainty with which it is determined, practically a more reliable guide to the steel maker and steel user than the very uncertain theoretical point. Engineers do not intentionally design their structures to carry a stress as high as the true elastic limit, even though such a stress is theoretically safe; the almost universal practice is to determine the grade of the steel by the simple commercial tests here described, and then allow for a stress which practice has shown to be thoroughly safe for the given conditions and the grade of steel used.

The next feature of the diagram, Fig. 4, that merits our attention is the maximum stress borne by the specimen before it finally begins to reduce in section or breaks. This is commonly called the ultimate, or breaking, strength of the material, although, owing

to the reduced area, the stress under which the specimen finally breaks is generally much less than the maximum, and *tenacity* a more satisfactory term, has sometimes been used to designate this important property of the material.

In order to keep the scale of our diagram as large as possible, that part beyond the point showing the maximum stress on the

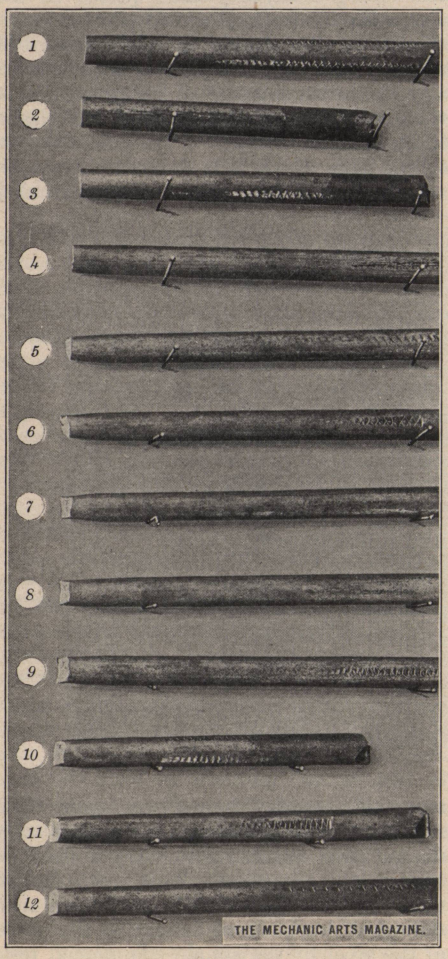


FIG. 5.

specimen was omitted; the total elongation of the specimen was 1.96 inches in the original length of 6 inches, or 32 per cent. of the original length.

The amount of elongation before fracture is a valuable index of the quality and properties of the material. The softer the steel, the greater, in general, will be its elongation. A high elongation is an indication of a metal of good quality, one that is malleable and ductile and will stand considerable deformation while cold, without being seriously injured—properties that are especially desirable in steel or iron to be used for boiler plates and rivets.

A very interesting feature of a tensile test is the reduction in area of the specimen at the point where it finally breaks; with the softer grades of steel the area of the fractured section is often less than half the area of the original bar, and the reduction sometimes exceeds 60 per cent. of the original area.

At one time a high percentage of reduction was thought to be an indication of a high quality of material, and this element is still given considerable weight in most commercial tests and specifications, especially for those grades of steel in which ductility and toughness are especially desirable qualities. If accompanied by a good degree of elongation, a high percentage of reduction at the point of fracture is an indication that the material has the desirable qualities of combined ductility and malleability; by itself, however, it may be merely an indication of a lack of uniformity in the diameter of the specimen or of homogeneity of the material, which results in a rapid failure at the weak point. These considerations have led some engineers to look on a high percentage of reduction with considerable suspicion.

There is yet one other element of the tensile test of iron and steel that deserves our notice. The character of the fracture is generally noted by the operator, and often by the inspector, when making commercial tests; since, however, this is a feature that cannot be directly measured and readily compared with some fixed standard, it is not given a great deal of prominence in most tests and specifications, although to an experienced observer it is regarded as a most valuable indication of the character of the material.

An excellent method of testing the ability of steel or iron to withstand the effects of severe distortion when cold, either from the processes of manufacture or during subsequent use, is by cold bending. Many specifications for steel to be used for members of bridges or for boiler plate and rivets—uses in which the metal is subjected to severe stresses and distortion during such operations as punching, shearing, flanging, and riveting—call for cold-bending tests, in addition to the tests made by a testing machine. The bending test has the advantage of

requiring no expensive outfit for its application, thus making it available where the more complete tests are impracticable; unfortunately, however, the methods to be employed and the significance of the results obtained have never been well enough standardized and classified to enable us to draw as correct inferences from such tests as the method seems capable of furnishing when properly developed. The "Manufacturer's Standard Specifications for Structural Steel" demand bending tests for the different grades of steel commonly used for structural purposes. The angle of the bend in each case is 180°, and the inner radius of the bend varies from 0 for steel having a tenacity of 62,000 pounds per square inch, or less, up to one-half of the thickness of the specimen when the tenacity does not exceed 70,000 pounds per square inch. The specimens must stand this test without fracture on the outside of the bent portion. Since, however, a quality of steel that is satisfactory in other respects will readily fulfil these conditions when carefully handled, bending tests made in accordance with these specifications appear to have little real value, and, until the methods of making such tests are properly standardized, the results obtained must be unsatisfactory.

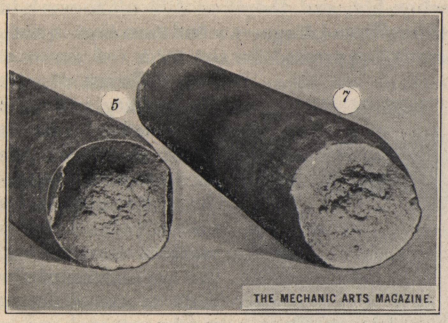


FIG. 6.

Figs. 5 to 10 are from photographs of a representative collection of broken and bent test specimens, and the accompanying table gives such chemical and physical properties as are usually determined for the various grades of steel illustrated by the different views. These specimens, for which the writer is indebted to Mr. C. S. Price, general manager of The Cambria Steel Company, are good average samples of the material produced by the Bessemer and open-hearth processes of steel making. They illustrate very clearly the results obtained by such tests as have been described, and will give the reader a very good idea of the great range of properties

No. of Specimen.	Chemical Properties. Percentage of					Physical Properties.					Process of Manufacture.	Use for Which Steel Was Made.
	Carbon.	Silicon.	Phosphorus.	Sulphur.	Manganese.	Elastic Limit. Lb. per Sq. In.	Ultimate Strength. Lb. per Sq. In.	Elongation. Per Cent. in 8 In.	Reduction in Area. Per Cent.	Character of Fracture.		
1	.64	.....	.....	.....	.....	87,140	145,300	10.0	17.8	Fine crystalline.	B.	.....
2	.71	.....	.....	.....	.95	81,480	146,400	5.0	7.8	Fine crystalline.	O. H.	Fork steel.
3	.53	.....	.....	.....	.....	76,960	128,300	11.0	22.6	Fine crystalline, center granular.	B.	.....
4	.42	.070	.099	.032	.90	74,020	121,550	12.5	22.6	Fine crystalline, center granular.	B.	Rails.
5	.12	.....	.....	.....	.....	43,000	62,480	28.0	55.6	Cup, silky.	B.	Wire.
6	.12	.....	.....	.....	.....	42,550	65,640	26.0	55.6	Cup, silky.	B.	I beams.
7	.10	.....	.....	.....	.....	39,380	59,520	27.0	57.3	¼ Cup, silky.	B.	Soft wire.
8	.14	.....	.....	.....	.76	48,900	70,400	25.0	46.2	¼ Cup, silky, center granular.	B.	.....
9	.44	.....	.045	.....	.48	52,060	88,280	20.0	38.1	¼ Cup, silky, center granular.	O. H.	Crankpins
10	.32	.....	.....	.....	.....	62,020	95,740	18.0	40.2	¼ Cup, silky, center granular.	B.	.....
11	.20	.....	.....	.....	.....	52,060	76,760	22.0	42.3	¼ Cup, silky, center granular.	B.	.....
12	.42	.....	.021	.030	.40	46,400	78,300	20.0	33.8	¼ Cup, silky, center granular.	O. H.	Car axles.

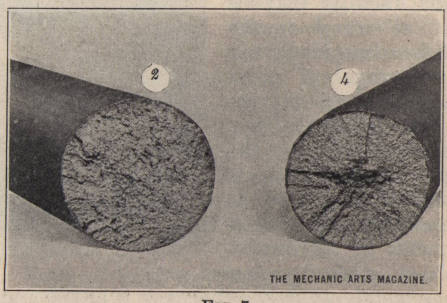


FIG. 7.

that are covered by the different materials classed together under the very indefinite name of steel.

An inspection of the table shows at a glance that the principal factor in determining the strength and hardness of the material is the percentage of carbon in its composition. Important as this element is, it is interesting to note how small a proportion is actually present, and what a narrow range of percentages is included between the $\frac{1}{10}$ of 1 per cent. of carbon in No. 7, the softest and most ductile specimen, and the $\frac{71}{100}$ of 1 per cent. in the hard and comparatively brittle material of specimen No. 2. These limits are seldom exceeded in steel made by the Bessemer and open-hearth processes, although more than 1 per cent. of carbon is sometimes found in special grades of open-hearth spring steel.

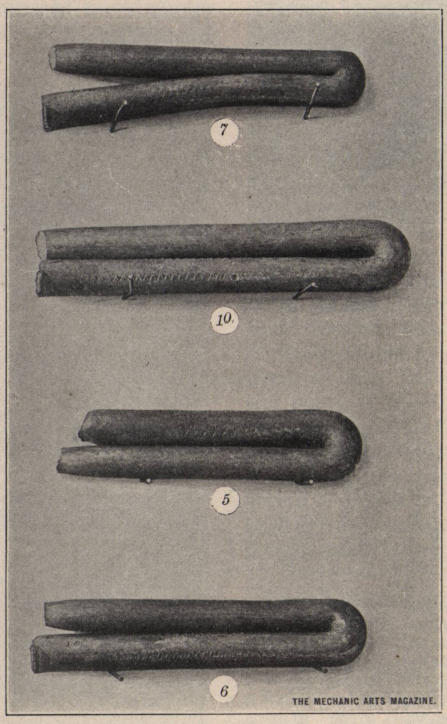


FIG. 8.

Of the other elements, phosphorus and manganese have a hardening effect, as will be seen by a comparison of the physical properties of Nos. 4, 9, and 12. The percentage of carbon is practically the same in each of these specimens, and the differences in their strength and ductility may be attributed to the differences in their percentages of phosphorus and manganese. Phosphorus, while it adds to the strength and hardness of steel, is one of the most undesirable elements in its composition, since it makes the metal *cold short;* that is, it is brittle and unreliable when cold.

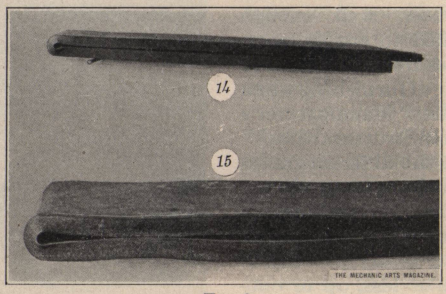


FIG. 9.

In its effect on the strength of steel, sulphur is not as marked as the other elements noted in the table, but it has the very undesirable effect of making the metal brittle when hot, and therefore difficult to work in the rolls and forge—a condition that is commonly expressed by the term *red shortness.*

The different degrees of ductility indicated by the columns in the table which give the percentages of elongation and reduction, are shown in a very marked manner by the appearance of the ends of the different specimens, as shown in Figs. 5 to 8. Figs. 5 and 7 show that the fractured ends of the harder steels, Nos. 1 to 4, have very little reduction from the original size of the bar, and that the fractured surfaces are comparatively flat, rough, and crystalline in appearance, and lie at nearly right angles to the length of the bar; this is especially true of the hard specimen, No. 2.

The different views of the softer specimens show very clearly the change in section that takes place when steel of this character is broken by a direct pull. They also show that the fractures, instead of being comparatively even and square with the bar, are very irregular. The fracture of such steel often takes a form which is commonly described as a *cup,* or *half cup,* one of the ends being either wholly or in part concave, as is shown in the enlarged end views in Fig. 6, while the other is correspondingly convex. In some cases, however, especially with flat bars, the fractured ends are nearly flat and smooth, but their surfaces, instead of being nearly at right angles to the length of the bar, as in the case of Nos. 1 to 4, form an angle of about 45° with it. Instead

of the rough, crystalline surface noted for the hard steels, the fracture of the soft grades has a surface which slightly resembles the glossy appearance of woven silk, thus giving the name "silky" commonly applied to this fracture. In many cases the broken ends of these bars of soft steel present a slightly fibrous appearance, almost like that of a bundle of the finest filaments of silk; in steel made by a process in which the metal is rolled or forged from ingots cast from a liquid mass there is, however, but little if any real fiber, such as exists in good wrought iron.

The centers of the broken bars of medium carbon steels generally show a dull and slightly granular structure, which gradually merges into the crystalline when the steel is comparatively high in carbon, or into the silky for softer grades. This condition is quite clearly shown in specimen No. 4 of Fig. 7 and the two specimens of soft steel in Fig. 6.

The results that may be obtained by bending specimens of good mild steel, cold, are very clearly shown in Figs. 8, 9, and 10. The number opposite each of these specimens corresponds with the numbers in the table and the preceding figures, with the exception of 13, 14, and 15, which are flat specimens, cut from soft bridge bars, probably rolled from steel of about the same grade as specimens Nos. 6 and 8. No. 13 was planed from a bar $\frac{15}{32}$ inch thick, and No. 14 from a bar $\frac{7}{32}$ inch thick; while No. 15 is a full-sized specimen from a $3'' \times \frac{3}{8}''$ bar.

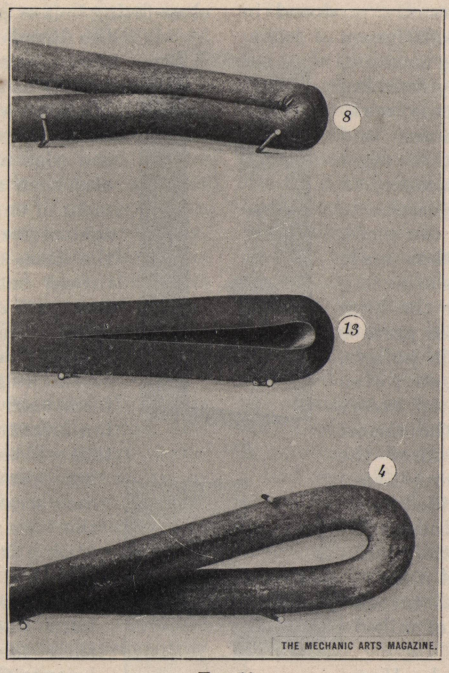


FIG. 10.

Specimens Nos. 7 and 8, Figs. 8 and 10, after being bent to an angle of 180°, were flattened under a heavy hammer until the thickness between the flattened faces is $1\frac{1}{8}$ inch in No. 7 and 1 inch in No. 8, the original diameter of the bars before bending being $\frac{3}{4}$ inch.

Specimen No. 4, Fig. 10, is particularly interesting as an example of the results that may be obtained with rail steel of a high tensile strength. This $\frac{3}{4}$-inch specimen was bent through an angle of more than 180°, as shown, to an inner radius of less than $\frac{3}{8}$ inch without cracking it on the outer surface of the bend; this is a test that is seldom demanded for steel having a tensile strength of more than 75,000 pounds per square inch.

It should be remembered that the tests here described and illustrated show the character of the steel when prepared according to a certain fixed standard; the operations of hardening, tempering, and annealing, or of working at a temperature much above or below the standard, will affect the character of the material as shown by these tests to a very remarkable degree. This is especially true of the high carbon steels; and it is on the proper control of these operations, nearly as much as on the original nature of the metal, that successful results are obtained in the manufacture of tools and springs. As the percentage of carbon decreases, the effects of variations in heating and sudden cooling become less, until, with the very softest grades, it is nearly impossible to produce a perceptible degree of hardening when the metal is suddenly quenched from a bright-red heat.

The tests of finished steel are made in practically the same manner as those just described, the principal difference being in the manner of preparing the specimens. For tests of bars and plates, the specimens are generally prepared by planing or milling from the finished material a rectangular piece about 20 inches long, having two sides covered with what is called the skin or scale formed in rolling; small bars are tested full size.

Tests of large or irregular pieces are made on carefully turned specimens, cut either from the full-sized piece or from a "coupon"—an extension forged on the main piece for this purpose.

BRIAR TEETH AND RAZOR EDGES.

By Inspector.

A Prevailing Workshop Practice That Leads to All Sorts of Trouble, and the Remedy Employed by a Leading Manufacturing Concern.

UNDER the above heading a few remarks will be made that may prove both interesting and instructive to those who are engaged in either making or using machinery.

In drilling a hole through a piece of metal, we get, as shown exaggerated in Fig. 1, a razor-like edge on the entering side, and a feather edge, or burr, of briar-like teeth on the other. Similar edges are produced in many other ways—in the lathe, on the planer, in the milling machine, in short, by almost every finishing tool—and there is perhaps no workshop practice so common and withal so bad as leaving these edges keen and sharp. For instance, on drilled work it is the practice to run the drill through the piece, and to call the hole thus made "finished," without removing either the razor edge or the briar teeth. The same practice prevails where holes are bored in pulleys, wheels, boxes, bushings, etc.; even where a hub is faced off before or after boring, it is the almost universal practice to allow the razor-like edge to remain; likewise, after reaming a drilled hole to exact size and roundness, the keen edge is left and the work passed as finished. And it is the same with the ends of turned shafting, and the edges of milled or planed work.

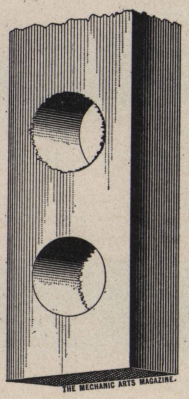


FIG. 1.

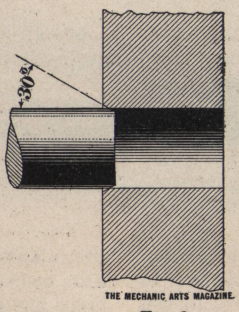
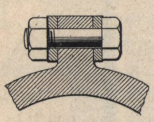


FIG. 2.

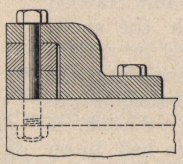
Now, all this is very bad. How many machinists that will not recall cases where, being unable to see to their satisfaction whether or not the holes in two or more parts to be bolted together were in correct alinement, they have thrust their finger in, to *feel* for what they could not *see*, only to be rewarded with a stab from a "briar tooth," or a gash cut half way around the finger from a "razor edge," edges previously passed as "finished"? Again, what engineer or machinist that has not found out by experience that, when making a final examination for rough places or bruises made in handling, or caused by the use of heavy tools in connection with the work, he runs the risk, when passing his hand around the end of a shaft, of having a crescent cut into his palm by the "razor edge" left when finishing in the lathe?

Did it ever occur to the reader that what happens to his finger under the above conditions may happen in a similar manner to a close-fitting bolt or pin? And the nature of the damage in the latter case is the more alarming, for the *hole* suffers as well as the bolt. Take the case of a shaft with keen end-edge, upon which bored work is being forced, the edge of the bored hole being also keen and sharp: at the moment of entering, the shaft bumps against the edge of the hole, part of the keen edge of the shaft being turned outward upon the shaft, and part of the edge of the hole being turned into the bore. The damage that this will cause depends on the weight of the parts and the force used to put them together, but briar teeth will thus be formed that will be a menace to all succeeding operations, and will in any case scratch both the shaft and the bore; if the shaft is a tight, forcing fit, it will probably "end up" and have to be forced out again, leaving the work in a mutilated and damaged condition; then the razor edges and the briar teeth will have to be removed and the work of assembling started over again. No amount of lubricating, either with oil or white lead, to reduce friction, and no other artificial means of smoothing the way, can take the place of properly preparing the work at the outset; this direct preparation should be done while the work is in the machine, and no work should be called finished until it has been done. In this connection we may cite the practice of a well-known and prosperous manufacturing concern—makers of bridgework, and of hoisting and conveying

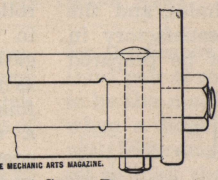
machinery, in which many such detail constructions as are illustrated throughout this article occur: To insure against the "unknown quantity" involved when sharp corners are left on, they have the ends of all shafts, tight-fitting bolts, and pins of every description turned off slightly at an angle of 30°, and the edges of all bored holes chamfered off in the same manner, as indicated in Fig. 2. With planed work, the same general principle is applied, but the angle of the chamfering is made 45°. This chamfering is a matter of business throughout the shops, and is done in as direct a manner as possible, and in the course of the other work—not as an after consideration, and not as if it applied in special cases only, but always and invariably. Likewise, it is understood throughout the shops that on all drilled work the burrs and sharp corners must be removed by the rise of a fluted tool of 60° angle, the tool used being made of such proportions as to take in a generous range of work.



SLIDING SLEEVE.



PARTS SECURED BY BOLT.



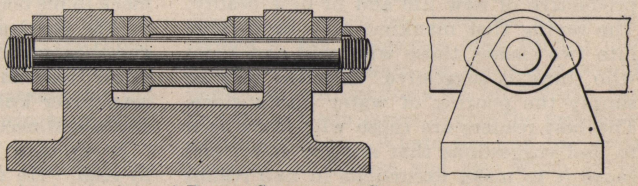
GUIDE BARS AND CONNECTION.

When holes have been finished in this manner, and tight-fitting bolts, pins, and shafts have had their sharp corners chamfered off as described, all tendency to jam or cut is at once removed; and the beveled edges obtained, though of but slight proportions, act to pilot, or direct, the course of the bolt, pin, or whatever it may be; thus, when a pin is to be passed through two or more parts, the chamfer enables it to draw the parts into correct alinement, preventing trouble from what would otherwise be a source of serious mischief and damage. As will be readily believed, this system materially reduces the cost of manufacture.

There is one commonly prevailing practice that deserves complete condemnation, and that is the allowing of drill hands to remove the burred edges that occur (more especially) on soft-steel plates and bars, by means of any "weapon" that happens to be within convenient reach, from a center punch to a half-round file, from the head of a cold chisel to a hammer (any old thing is considered good enough on drilled work), with which to "stab," "pick," "slash," or "clout" the edge of a drilled hole into what he considers "good shape." Now, in every such case, irrespective of the kind of material being worked on, he will turn much of the offensive burr back *into* the hole, and while he may succeed in removing the larger part, he cannot avoid leaving the edge in a badly damaged condition—a condition that may be fruitful of serious and costly trouble later on.

It was not the writer's purpose at the outset to make any special mention of drilling tools as such; yet it may be entirely in order and of some service to point out that the amount and character of the burr on the under side of a drilled hole is very largely dependent on the condition of the drill itself. A dull drill always forces out a large burr, and in addition tends to bulge the work itself, while a keen drill, properly ground, will produce clean work, with small burrs and no bulging whatever.

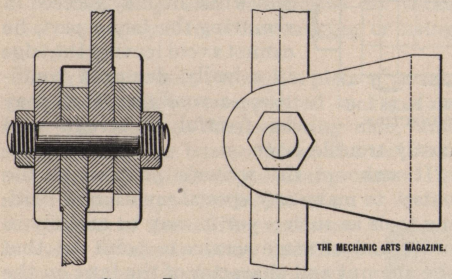
There is more than one good way of removing a burr from drilled work, though the best is to employ the fluted tool already described. Where it is desired to perform the operation by hand—in cases, say, where only a small number of pieces are to be done at one time—the next best thing is to have a tool resembling a carpenter's brace, but specially adapted to firmly hold the shank of the fluted tool. It should be explained that the flutes in this tool should be irregular in depth and spacing, so as to avoid the chattering and consequent "chatter marks" that will otherwise be produced on most metals. If correctly made, the same tool can be used with satisfactory results for holes up to 2 inches in diameter.



A BOLTED STRUCTURAL CONNECTION.

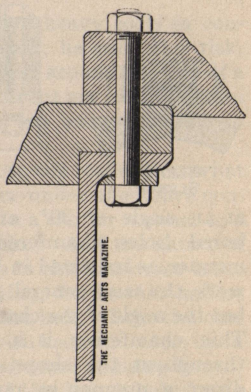
For holes larger than 2 inches, and where the surface of the hole is curved, or irregular, or not at right angles to the hole, a hand scraper can be used with advantage. A very

desirable double-edged scraper for this work can be made out of an old file, say 8 or 10 inches long, by grinding off the teeth until two perfectly clean-cutting edges are obtained. When once familiar with the use of a tool of this kind, the workman will find it an easy matter to remove the burred and the sharp edges from holes, and the resulting condition will be satisfactory in every way. The tool cannot be prepared too carefully, because it will last for a long time without being resharpened.



CHORD BARS AND CONNECTION.

Not long ago, it became a matter of importance to the writer, in connection with a certain job, to obtain tight forcing fits with the lowest possible forcing pressure, as indicated by the hydraulic press. One day, a shaft 3 inches in diameter was being pushed into a hub 10 inches long, when the gauge indicated a pressure much higher than was admissible for the thickness of stock in the hub, showing that the fit was too tight. On removing the shaft it was found that the old story was being told over again: A small sharp burr on the edge of the hole had been turned in when the shaft was entering, had rolled and crawled in with the shaft, gathered in volume as it went along, and finally balled up into a wad, which, if pressure had been continued and increased, would have gradually grown until an infinite pressure would have been required to move it. Even as it was, when the shaft was forced out in the direction it had been entered, it carried along with it a large portion of the face of the hub, and consequently completely disfigured the work.



A BOLTED DETAIL.

Careful consideration of this subject will demonstrate that on all classes of machine work it pays to remove the "briar teeth" and "razor edges."

HOW TO READ.

Extracts from an Essay by the President of Lake Forest University.

THE successful reader is one who thinks more than he reads. The advantage of reading is in the obtaining of information or ideas which are then brooded over, as a hen broods over her eggs, and are made productive of new life and of new beauty. The saying that mankind may be divided into two classes, those who read and those who think, is suggestive. Reading may be simply the pouring of water into a sieve. The best readers are those who know how to find suggestions that stir the mind and cause it to make excursions in new realms of thought. Almost any worthy book that comes into our hands will bear more than one reading. Indeed, all great books must have more than one reading if they are to be appreciated.

Were I to state the prime requisite of successful reading, I would say that it is attention. Many persons read without being able to get a clear opinion at the conclusion of their reading as to the ideas that have been before them. I knew a young man, a student of the law, who was accustomed to put a mark in his book at the page he had reached in his reading. His roommate every now and then would place the book mark several pages back in the volume, and the young man never knew the difference. Attention sometimes necessitates very slow reading.

Every man has to learn for himself how to read. He must know why he wishes to read, and then he must know what he wishes to read. Then, in due time, if he reads to develop thought and to insure accurate expression, he will acquire habits of selection and of proportion that will make his reading a success to himself and a blessing to others.

IN THE WORKSHOP.

(*Continued from the May, 1899, Number.*)

H. Rolfe.

LONG VERSUS SHORT BOILER TUBES—IMPORTANT CONSIDERATIONS GOVERNING THE LENGTH. FIGURING ON DRAFT AREA.

IN CONNECTION with the subject of locomotive tubes, there are other directions than that mentioned in our last in which a good thing is often "overdone"—in that of length, for instance.

Of course, the length of a boiler tube is to a great extent fixed by the type and design of engine. Speaking generally, the length depends on the wheel base, which in turn depends on the type of engine, the size of drivers, and the nature of road (as to curves). Supposing an eight-wheeler is being laid down; we know beforehand what work the engine is to do, and the kind of fuel to be burned, and have decided on the steam pressure and the size of the cylinders and wheels. We therefore know what the grate area will have to be. If for bituminous coal, we can generally put the firebox in between the main and the rear axle, without getting too long a side rod; having settled on the wheel base for the drivers, we know pretty well where our truck will be with a view to good distribution of the weight. The determination of this locates our cylinders and, practically, our front tube sheet also; and, the back sheet being already located, our tube length follows.

Sometimes an extra inch or two of width is obtained by making the upper frame brace of slab form from the main to the rear driver. We think it preferable, on the whole, to lift the box up above the frames and so get yet another two or three inches; then, also, more latitude ensues as to tube length, as the box can be carried back somewhat and a longer tube used. But we cannot do much as regards *shortening* the tubes, being restrained by various considerations, such as allowing proper clearance for the eccentrics, and also for the springs—in some kinds of spring rigging.

For bituminous coal the box can be shortened and so a longer tube obtained without increasing the wheel base. With both eight- and ten-wheelers, the box, when it is above the frame, can be carried back over the rear axle and a longer tube used, without increasing the wheel base. In consolidation engines we naturally have long tubes, for the firebox has to be kept back of the third pair of coupled wheels, assuming them to be the main drivers. In eight-wheelers, when a large barrel occurs in conjunction with large drivers, the boiler has often to be set so high that a firebox of normal depth naturally takes a position above the frames. The designer should see to it that the tube is not too long for its diameter; when previously settling on the draft area he will have known approximately what the tube length would be, and have so chosen the diameter as to prevent undue sagging. Sometimes tubes are given a slight camber to overcome the tendency to droop.

In choosing the diameter, the two extremes are to be avoided. As pointed out last month, there are many evils that result from the tubes being too small; and if too large, heat will be wasted and the draft will be sluggish, but, on the other hand, the flame will remain alive further in the tube, and thus more perfect combustion will ensue, and more of the heat from the coal be given to the water.

As already stated, the tube length is largely fixed by other considerations, but designers have ere now gone out of their way to obtain a long or a short tube, according to their individual preference. In Europe we have seen six-wheeled engines with overhanging cylinders and fireboxes; that is, the whole box was behind the rear axle. This was done not only to keep the wheel base short (being rigid throughout), but also to admit of a longer barrel and therefore longer tubes. On the other hand, where the boiler has been set above the frames, it has sometimes been carried just about as far forward as clearances would permit, so as to cut down the tube length, the box being made larger to give the necessary heating surface. Where the box has been between the frames, and also when above them, the main drivers and truck have been brought closer together with the above aim in view. Often, too, the box has been set back bodily, to get a longer barrel while keeping the wheel base the same. Now, the first design (the six-wheeler) is not likely to be perpetuated, but the other practices

may be repeated, and we simply point out how, in each case, a thing may be carried to extremes. The tendency of a good many designers *is* to cut down the tube length, knowing that, area for area, it is of much less importance than the firebox sheets, but still the tubes are by no means cold bodies—in fact, from one-half to five-eighths of the steam making is done by them. So long as the gases escape from the front end of the tubes at a temperature of from 600 to 700° F., as is the case when an engine is working hard, there is good work for the tubes to do, the temperature of steam at 180 pounds pressure being only about half of the above. It is when you are going to use a high rate of combustion (which means a fierce draft and rapid flight of the hot gases to the stack) that you need a long tube so as to prolong the heat-absorbing process.

Before leaving this subject of tubes, we may caution the young designer against losing sight of the fact that the draft through the tubes is decreased by the ferrules in the back tube sheet, particularly when they are *inside* the tubes. The mistake has been made before now of simply taking the normal bore of the tube into account and forgetting that it is really the ferrules that govern the gross flue area; and, as it happens, the ferrules are put into the smallest end of the tube—an unfortunate coincidence. We say "smallest end of the tube" because the holes are usually made from $\frac{1}{16}$ to $\frac{1}{8}$ inch larger in the front tube sheet, to make it easier to draw the tubes when renewing or reending. So the ferrules should not be forgotten.

Now, the point may occur to many: Is all the thoughtlessness confined to designers? Are there not cases where the mechanic overdoes it sometimes? Well, yes, there are, and we will try to present a few instances next month in the form of a mild indictment against the shopman.

(To be Continued.)

TYCHO BRAHE.

George McC. Robson, M. A.

THE TYCHONIC SYSTEM OF THE UNIVERSE—THEORY IN CONFLICT WITH OBSERVATION—ANCIENT ASTRONOMICAL INSTRUMENTS—A MODERN HINDU RIVAL OF TYCHO BRAHE.

THE pages of this magazine frequently contain descriptions of the superb scientific instruments and wonderful machines devised and constructed in these latter days to assist the scientist in his investigations and the laborer in his work. The most abstruse researches of theoretical science, the greatest undertakings of practical engineering, and the simplest affairs of life are alike facilitated by an equipment of appliances, each of which requires for its construction the accumulated knowledge of ages, and the mechanical skill developed by the training of successive generations for centuries. The employment of these appliances is such a familiar experience that one almost forgets that they are not as much a part of his natural environment as is the atmosphere; and when the scientific and engineering triumphs of the last decade are reckoned up, due credit is not always given to the long line of faithful toilers who, in former decades, patiently and laboriously laid up the store of knowledge that makes these triumphs possible. When one rejoices over the progress of this progressive century, it is well to abstain from imitating the nobleman that boasts of the number of birds he has killed, and forgets to mention the assistance he received from the gamekeeper. At the close of a busy and successful day, when one feels that he has accomplished something to earn a night's repose, it is interesting to consider how much of the day's work he could have performed by his own unaided efforts, and how far he is indebted to external assistance: his breakfast hour is regulated by a watch constructed with marvelous mechanical skill, which he possesses not; he rides to his office in a car propelled by a mysterious power of which he, perhaps, knows little; his letters are written in indelible ink, on smooth white paper, with a fine steel pen, none of which were made by him; his messages pass under three thousand miles of stormy seas, over a cable which his brain did not plan, and which was not laid by the toil of his hand; his merchandise is borne to distant lands in a stately ship, though he did not devise the subtle conscience—called a compass—that directs her path, nor did his genius subjugate the monster whose throbbing mighty heart supplies her motive power;

if he is an engineer or an astronomer, he is continually using mathematical tables and formulas that the labor of his whole life would be insufficient to calculate independently, and he uses delicate instruments that he could not construct for himself. A distinguished writer has said that Kant was an intellectual Melchizedek—without father, without mother, without descent, having neither beginning of days nor end of life—which is a somewhat metaphorical way of saying that Kant was intellectually a self-made man and owed nothing to preceding philosophers. This may be true of the great philosopher, but it is absolutely certain that no such statement can ever be true of any worker in the domain of pure or applied science, or even in the most trivial affairs of life; whether we will or no, we are the heirs of the ages, and we can by no means escape from our inheritance.

Tycho Brahe is, in many respects, the most picturesque and interesting personage in the honor roll of great men that have amassed for us our precious heritage of skill and knowledge. The stock of knowledge that he inherited was very meager compared with the vast treasure that has come to us, and he had practically no inheritance of mechanical skill and mechanical apparatus. Small as his heritage of skill and knowledge may appear to us, to him it seemed great; and he promptly took possession of it, and endeavored to make himself so thoroughly master of it that he could use it effectively, and he resolutely set himself to investigate the great problems of nature with the aid of the rude instruments used by his predecessors and such improved apparatus as he could fashion for himself.

TYCHO BRAHE.

Tycho Brahe, the second child and eldest son of Otto Brahe, a Danish nobleman, who filled with credit an important office in the government, was born on the 14th of December, 1546, in what was then the Danish province of Scandia, but is now the southern extremity of Sweden. Otto Brahe, on the occasion of his marriage, had made an agreement with his brother George, who was childless, that George should adopt the first son that should be born to Otto. On the birth of Tycho, Otto and his wife refused to surrender their son to George, and he acquiesced in their decision at that time; but, on the birth of Otto's second son, George resolved to assert his claim to the elder son, and stole little Tycho. Thus it came to pass that Tycho was educated by his uncle, whose chief ambition was to have the boy thoroughly trained in philosophy and rhetoric, to fit him for a career of statesmanship.

Tycho began to study Latin at the age of seven, and entered the University of Copenhagen at thirteen. His early entrance at the university does not indicate any precocious or phenomenal cleverness; for we must remember that university requirements for entrance were then much more limited than now. The mathematical attainments of the average university student of that time may be gauged from the fact that in the University of Wittenberg the professor of mathematics was accustomed to encourage his students by assuring them that even the processes of multiplication and division in arithmetic could be learned by diligent students of average intelligence.

On the 21st of October, 1560, there occurred an eclipse of the sun, which was visible at Copenhagen, and Tycho was filled with amazement that the event could be accurately predicted. He obtained a Latin version of the astronomical works of Ptolemy, in which he diligently sought for the explanation of the methods by which such predictions were made; this book—marked and annotated in his boyish writing—is preserved as a priceless relic in the University of Prague. His mind was thus definitely turned to the study of the heavens, and from this time he spent his money and his energy in the pursuit of astronomical knowledge. His uncle used

every effort to divert him from natural science, which was then considered beneath the notice of a nobleman, and even engaged a tutor to prevent the youth from wasting, in so frivolous a pursuit, the valuable time that should be devoted to the serious study of philosophy and classical literature.

At the age of seventeen, Tycho began a series of systematic observations for the purpose of computing the places of the planets. His only instruments were a pair of compasses and a divided circle. Placing his eye at the joint of the compasses he opened the legs until they pointed to two stars; then he laid the compasses upon the divided circle, and thus found the angular distance between the two stars. In this way he soon found that the actual places of the planets differed widely from those recorded in existing books.

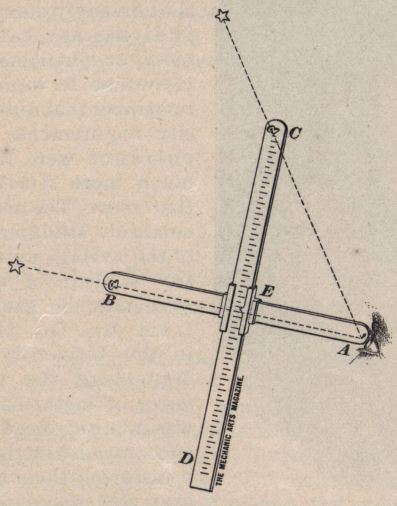


FIG. 1.

Later, he succeeded in obtaining, without the knowledge or consent of his tutor, a cross-staff, which was an instrument much used by preceding astronomers. The cross-staff is shown in Fig. 1. The bar $A\,B$ slides along the graduated bar $C\,D$ in such a way that the two bars are always perpendicular to each other. At A, B, and C are placed "sights," like those of an old-fashioned rifle. In making an observation, the eye is placed at A, and the instrument is so adjusted that one star is seen in the line $A\,C$, while another star is seen in the line $A\,B$. The distance $C\,E$ is read upon the graduated bar $C\,D$, and then the angle $B\,A\,C$ is found by reference to a table previously constructed. This primitive instrument, in the hands of so skilful an observer as Tycho, gave surprisingly accurate results. In using it, Tycho set the most excellent example of making systematic corrections for instrumental errors, and this example is followed by every astronomer today with the finest instruments that modern skill can make. In order to gain opportunities to use his cross-staff he had to exercise as much ingenuity to escape the vigilance of his tutor as was required in guarding against the errors of the instrument. However, he was soon relieved of all restraint upon his inclinations by the death of his uncle, which occurred when Tycho was nineteen. Tycho then proceeded to the University of Rostock. During his residence there he wrote some verses on the occasion of an eclipse of the moon, which happened on the 28th of October, 1566. In those verses he declared that the eclipse was to announce the death of the Sultan of Turkey, and as the Sultan was considerate enough to die at that very time, these verses gained for Tycho a good reputation as a reliable prophet. At this period Tycho had another very characteristic adventure—he lost a piece off his nose in a duel with another Danish noble, and made for himself an artificial nose of a composition of gold and silver. The artificial nose is said to have been as good as the original, though the historian has forgotten to state whether this remark was made by a partial friend or a satirical enemy.

About this time Tycho became interested in the pseudoscience of alchemy, which bears the same relation to chemistry that astrology bears to astronomy. It was inevitable that one so deeply interested in astrology should pay some attention to alchemy; for the astrologers and alchemists held that each planet was in some mysterious way correlated to a particular metal, and the two pseudosciences were very closely connected in men's minds.

He was recalled to the work in which he was destined to achieve such great results by a startling event that happened on the 11th of November, 1572. Returning to supper from his laboratory, he beheld an extraordinarily brilliant star where no star had been visible before. The appearance of the star was so unusual that he summoned his servants to assure him that he might trust his senses. New stars have frequently been observed, but we have no record of any at all comparable to this one in brilliancy and splendor; it was so bright as to be plainly visible in broad daylight. Immediately every person who made any pretense to be an astronomer began to speculate about this

prodigy, and to make observations and measurements of the position of the star. The observations and determinations of Tycho far surpassed all others in completeness and accuracy; indeed, he discovered everything that could have been discovered without a telescope. He proved that this brilliant object was a fixed star whose distance was far too great for measurement, and he carefully recorded the variations of its brightness.

These thoroughly scientific and very important conclusions were in his mind entirely subordinate to the great astrological significance of the prodigy. He says "the star was first like Venus and Jupiter, and its effects therefore will at first be pleasant; but as it then became like Mars, there will follow a period of wars, seditions, captivity and death of princes, and destruction of cities, with dryness and fiery serpents in the air, pestilence and venomous snakes. Finally, the star became like Saturn, which presages a time of want, death, imprisonment, and all kinds of sad things." In commenting on this passage, Kepler says, "If that star did nothing else it at least announced and discovered an astronomer." Tycho wrote a book setting forth his observations and conclusions regarding this star, but delayed the publication of it in deference to the wishes of his friends, who held the writing of books to be derogatory to the dignity of a nobleman.

NICHOLAS COPERNICUS.

This book, when published, attracted the notice of the King of Denmark, who invited Tycho to return to Denmark and deliver a course of astronomical lectures in the University of Copenhagen. Tycho accepted the king's very liberal proposal, and his inaugural lecture has been preserved. In it he speaks in glowing terms of the beauty and interest of celestial phenomena; he asserts the importance of continuous systematic observation; and he maintains that the science of astronomy is of immense practical utility as the only means of measuring time, and as enabling us to predict human fate from the motions of the heavenly bodies.

Now that our hero is fairly embarked on his career as an astronomer, let us consider what he derived from his predecessors. The astronomical works of Ptolemy, already alluded to, contained almost all the astronomical knowledge of the ancients that was of any value. In addition to these works he had the Alfonsine tables, which were calculated by order of Alfonso X of Leon and Castile, and published on the day of his accession in 1252; he also had the Prussian tables published at the expense of Duke Albert of Prussia, and revised from the calculations of Copernicus by Reinhold, who was professor of mathematics and astronomy in the University of Wittenberg from 1536 to 1553. Both of these sets of tables abounded in errors, many of which were quite serious; for example, in 1563 Tycho observed the close approach of Jupiter to Saturn, and found the time predicted by the Alfonsine tables to be a full month wrong, while the error in the time predicted by the Prussian tables amounts to several days. In theoretical astronomy the only advance upon the Ptolemaic system was the magnificent but uncorroborated speculation of Copernicus. The Copernican theory could then derive no support from the science of mechanics, which was still undeveloped, and it had not been sufficiently established by agreement with observations. Copernicus himself had made little effort to test his theory by observation. Indeed, he can base no claim to astronomical fame upon his skill or success as an observer; he lived in a latitude and climate unfavorable to such work; his instruments were of his own construction, and were far inferior to those used by earlier astronomers; he was an unskilful observer, and in one case made an error in the position of a star amounting to 40′, which is more than the apparent diameter of the sun. His pupil, Rheticus, urged upon him the importance of the greatest accuracy of observation. But Copernicus maintained that such accuracy was then unattainable and unnecessary, and that a rough agreement between the theory and the observed phenomena was all that could be expected until more accurate means of observation could be devised. He owes his exalted

position in the foremost rank of astronomers to his boldness and readiness as a theorist and to his ability as a mathematician. In common with all scientific pioneers he was a diligent and reverent student of the works of his predecessors, and was deeply read in the literature of mathematics and astronomy. It is sometimes assumed that he despised the ancient theories as mere idle superstitions, and he is honored because he broke loose from the shackles of those superstitions, and produced a complete new theory of the universe from his own brain, as Minerva sprang all-armed from the brain of Jupiter. Nothing could be farther from the truth. With characteristic modesty Copernicus claims no credit for his discovery, but attributes it as far as possible to the ancients; he quotes Philolaus and other Pythagoreans as authority for the doctrine of the earth's motion. Moreover, the theory propounded by him was by no means the complete Copernican system expounded in modern books. The one great principle upon which he insisted was that the apparent motions of the heavenly bodies are partly due to the motions of the earth; and he made no attempt to dispense with the Ptolemaic cycles and epicycles.

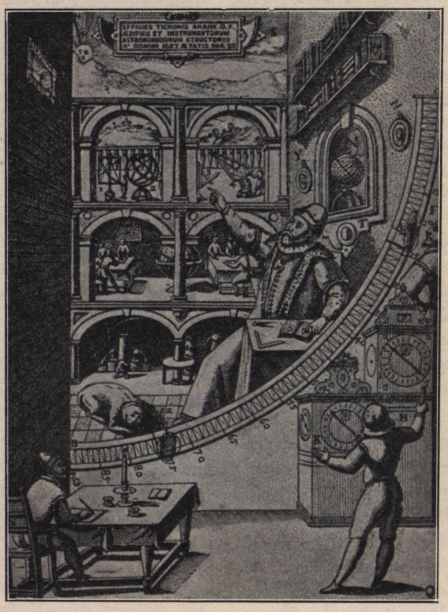


FIG. 2.

One grave objection to the Copernican theory was then and for long afterwards unanswerable. The essential point of his theory is that the motion of the earth causes an apparent motion of the heavenly bodies, and yet no such apparent motion of the fixed stars could be detected. If the earth describes a great orbit about the sun, the position of the earth at any time is separated from the position it occupied six months before by a distance equal to the diameter of this orbit; and by the reasoning of Copernicus this displacement of the earth should cause an apparent displacement of every star. Copernicus recognized this difficulty, but with wise and commendable audacity held to his theory, though unable to explain this apparently glaring contradiction. This is by no means a solitary instance of a true theory being in danger of rejection because of its conflict with the results obtained by experiment or observation, and the adherents of the despised theory require high courage and firm faith to withstand the sneers of contemptuous opponents and the irritating sympathy of skeptical friends. Of course, Copernicus could not have persisted in adhering to his theory if he had been convinced that it was contrary to the actual facts. He therefore took refuge in another speculation even more startling to the ancients than the doctrine of the earth's motion; he supposed that the fixed stars were so far distant that their change of position due to the earth's annual motion could not be detected, and he further supposed that the fixed stars were all at the same distance from the earth. The idea that the stars were at the same distance was the universal belief of ancient astronomers, but the speculation as to their enormous distances was simply suggested to him by dire necessity. He reasoned in the following manner: Suppose the earth in six months moves from E to E' (Fig. 3), and that S is the position of a fixed star; then the angle $E\,S\,E'$ measures the apparent displacement of the star due to the earth's motion. Now, if the distance $E\,S$ is 300 times the distance $E\,E'$, the angle $E\,S\,E'$ is less than $12'$, and with the instruments of the time it was scarcely possible to detect so small a quantity. He believed that a time would come when, with improved instruments, astronomers would be able to detect this displacement of the stars. His hope has been fulfilled, his wild speculation of the enormous distances of the stars has been more than justified, but the belief that the stars were at equal distances, which he shared with the best practical astronomers of his day, has been shattered completely.

The book in which Copernicus published

these startling speculations excited little opposition at the time, chiefly because it was written in technical language, and could be read only by trained mathematicians.

The theoretical astronomy developed by Copernicus, however imperfect it may seem to us, was nevertheless far in advance of the practical astronomy that had for its object

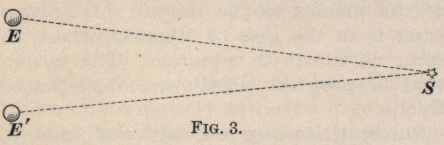


FIG. 3.

the making and recording of accurate observations. Further progress in theory could not be looked for until a practical astronomer should arise and, with improved instruments, make accurate observations by which the theory of Copernicus could be verified or corrected, and provide materials for those profound thinkers who were to correct and advance the theory.

This arduous task fell to the lot of Tycho Brahe, who was most admirably qualified for it. Tycho resembled Copernicus in his familiarity with and reverence for the learning of the ancients, but differed widely from him in other respects. Tycho was far inferior to Copernicus in power of keen speculation, but excelled in mechanical skill and in all those qualities that make a successful experimentalist. It is to be observed that Tycho entered upon his work with no intention of verifying the Copernican theory; indeed, he ultimately rejected that theory, and proposed a scheme of his own, which is shown in Fig. 4. His principal reason for rejecting the Copernican system was the enormous distances that it necessarily assigned to the stars, because there would thus be a vast void space between the stars and the planets, and he could not believe that nature would waste so much good space. His own system is a compromise between the Ptolemaic system and the Copernican. He supposed that the sun revolved in an annual orbit about the earth, and that the planets revolved about the sun, while the whole celestial sphere performed a daily revolution about the earth. The details of this system were never worked out, and it was never accepted by any competent astronomer.

In the year 1576 the King of Denmark gave Tycho the island of Hven as a site for a splendid observatory, for which the king supplied ample funds. The foundations of this observatory were laid with most imposing ceremonies. Here Tycho erected his great mural quadrant, which is illustrated in Fig. 2. By means of this wonderful instrument he was able to determine the altitudes of the stars with far greater accuracy than had ever before been attempted. In the illustration Tycho is seen using the mural quadrant, with the aid of his pupils.

Tycho was now in the zenith of his fame; students flocked to study under him, and the king defrayed the vast expenses of his great establishment by lavish grants from the royal purse. In the seclusion of his island observatory, he pursued his work for twenty busy years, and accumulated a splendid series of observations far surpassing in exactness anything that had been done by his predecessors. His fame rests solely upon the completeness and wonderful accuracy of these records.

In 1596 a new king ascended the throne of Denmark, and he withdrew the grants to Tycho. Tycho therefore left Hven and

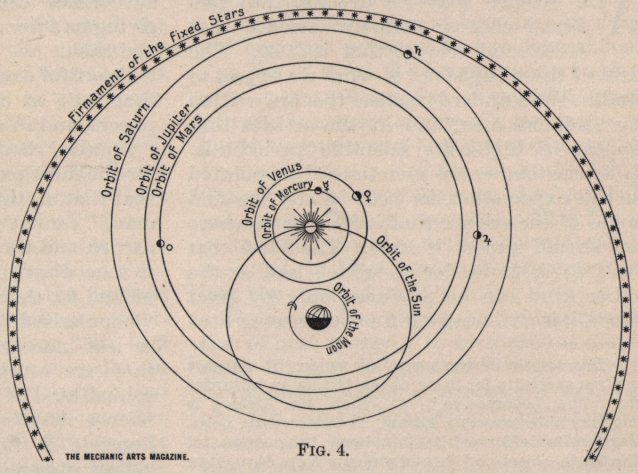


FIG. 4.

went to Bohemia, where he died in 1601.

Tycho's modern rival bears the euphonious and easily remembered name of Mahámahopadhyáya Samanta Sri Chandrasekhara Simha, and is a native of India. The Hindus have never adopted the Gregorian calendar, and the errors of their own calendars have accumulated to an intolerable extent, and great confusion arises from the

fact that no two of their almanacs agree. To correct their calendar and regulate their religious observances, it was necessary to determine the exact length of the year, and this can be done only by astronomical observations. This Hindu astronomer of the nineteenth century set himself to this task with even less external assistance than Tycho; he also had to fashion his own instruments, but without the aid and encouragement that Tycho received from a generous king and from pupils that were themselves able mathematicians and skilled astronomers. The Hindu astronomer's store of inherited astronomical knowledge was altogether insignificant, consisting merely of rude records dating from the twelfth century and earlier. Any one familiar with the routine of a well-equipped observatory will have a feeling of sympathy for this Oriental toiler constructing his own instruments and recording his observations upon a palm leaf. His success can be estimated from the following figures: The errors in his determination of the sidereal periods of the sun and moon are 206 seconds and 1 second, respectively; in determining the inclinations of the orbits of the planets to the ecliptic, his greatest error is in the case of Mercury, where his error is about 2 minutes. The system that he proposes closely resembles that of Tycho.

Surely these men are worthy of immortal honor for their devotion to the pursuit of knowledge, and for their patient endurance in the work of wresting from nature the secrets by which millions of their fellow men may regulate their daily routine.

MAGAZINE SCIENCE.*

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A. D. Risteen.

A Just Criticism of a Few of the Misleading Scientific Articles That Have Appeared Recently in Some of the Most Popular Monthly Magazines.

ALL science may be divided into two broad classes; namely, science that *is* so, and science that *isn't* so. The first of these divisions is what we expect to find in the standard treatises that are written by eminent men, and in the articles that appear in high-class scientific periodicals. It is true that we are sometimes disappointed in this expectation, for occasionally we find some of the science that *isn't* so, even where we should expect it least. The kind that isn't so is far easier to write; and as the other kind can be produced only by great labor, it is not strange to find our most trusted authorities occasionally going astray, and giving us a few paragraphs of foolishness now and then.

Beautiful examples of the kind of science that *isn't* so can be found in the newspapers, and in a good many of the so-called "popular" books. Such books are written, for the most part, by men who have an idea that that mythical individual, "the average man," cannot understand the real facts of nature, and they appear to think it necessary to tone down those facts and smooth them off and fix them up and elucidate them by "popularized" illustrations that are more or less inaccurate, until their books, when they are completed, contain much of the second kind of science; that is, much of the science that *isn't* so. All of which is reprehensible in the extreme. It is also altogether unnecessary, as is evident from the few really first-class popular books that have been produced—Tyndall's "Heat Considered as a Mode of Motion," for example.

To the two classes of science into which most writings can be divided, and which are mentioned above, an intermediate division, or *subclass*, may be conveniently added, so as to include the science that is *almost* so, but *not quite*. For science of this sort we

*This article is worth reading twice. It was not written specially for these pages, but as an editorial for "The Locomotive," of which Mr. Risteen is the very able Associate Editor. It is, however, peculiarly suitable for publication here, because one of the main objects of The Mechanic Arts Magazine is to teach clearly the science that *is* so. This is, in itself, no easy task, but it is made infinitely more difficult than it really should be by the publication in newspapers—and especially in the Sunday editions—of much sensational science that *isn't* so. The unfortunate part of it is that, whereas the Sunday paper comes weekly and is read and believed by the million, the educational periodical comes but once a month and then only in thousands. We consider it the bounden duty of every reader of this article to persuade at least one other person to read it.—Ed.

propose the name "Magazine Science," since it is in our leading magazines that such science is nowadays most prominently put forth. Magazine science, as thus defined, may degenerate at times into the kind of science that is *not* so, but it seldom rises so as to be clearly in the class that *is* so.

It isn't long since "Harper's Magazine" published a roseate article on the Jacques carbon battery, in which the vast possibilities that were said to be before that battery were suggested in the most hopeful terms. This battery attracted a great deal of attention from the general public, and with the apparent endorsement of a magazine as favorably known as Harper's, it would have been easy (we should think) for an unscrupulous man to have organized a company that would have taken many good dollars from men who could not afford to lose them. We do not mean to imply that Dr. Jacques had any such idea in his head; but we *do* mean that a magazine that is well known and widely read and trusted takes a great responsibility when it publishes an article that leads thousands and thousands of readers to believe that a great and probably profitable invention or discovery has been made, when it really has not been made. We discussed the Jacques carbon battery in the issues of "The Locomotive" for August and September, 1896; and the correctness of our view of the matter has been substantiated by the fact that the carbon battery has now fallen, to all appearances, into innocuous desuetude.

A recent and widely-discussed example of "magazine science" occurs in "McClure's Magazine" for March of this year, where Mr. Ray Stannard Baker writes of "Liquid Air." The article contains much that is of deep interest, and some things that are not so. With one or two exceptions, the portions that treat of the *experimental* data are apparently correct, while the portions that deal with theoretical principles are sadly in error. This is probably due to the fact that neither the writer of the article nor the experimenter (Mr. Charles E. Tripler) are very well informed on the subject of thermodynamics.

This article on liquid air has already received much rough treatment from the technical journals and the newspapers, and we have no desire to add to the condemnation that has been heaped upon it. We have received a good many inquiries about it, however, and our readers appear to expect us to go on record in the matter upon one side or the other, and so we shall give our views as briefly as possible.

The part of the article which has provoked hostile criticism is that in which Mr. Tripler speaks of running an engine with three gallons of liquid air, and using the power so developed to drive a compressor which produces ten gallons without being supplied with any mechanical energy save that obtained from the three gallons used in the engine. Many of the critics of the article appear to scent a perpetual-motion scheme here, in spite of Mr. Tripler's earnest disclaimer. Mr. Tripler says that the heat *of the surrounding atmosphere* is boiling the liquid air in his engine and producing power, just as the heat of coal boils water and drives off steam, which develops power in the steam engine. He says that he is merely converting the natural heat of our atmosphere into mechanical energy, instead of following the usual plan and obtaining the heat to be so transformed by means of the combustion of coal. This explanation is a peculiarly seductive one, because to the general reader who has not made a study of the theory of heat, it appears to be rational and by no means impossible, nor even improbable. There is an obstacle in the way of such a project, however—an obstacle known as the "second law of thermodynamics."

The transformation of heat into mechanical energy is governed by two general laws. The *first* of these laws states that whenever such a transformation does take place, whether in a steam engine or a gas engine or a liquid-air engine or a heat motor of any other kind, a perfectly definite amount of heat disappears for every foot-pound of mechanical energy that is produced. This law is quite well known, and there is nothing in the article in "McClure's" which contradicts it in the smallest particular.

The *second* law governing the transformation of heat energy is by no means as easy to state. It may be presented in several different forms, whose equivalence is not at all obvious. In the simplest of these forms, the second law consists in the statement that heat always tends to pass from a hotter body to a colder one, and that it cannot be made to pass in the reverse direction (that is, from a colder body to a hotter one) without the expenditure of energy. (When so stated, the law may be compared, for the sake of clearness, with the fact that water always tends to pass from a higher level to a lower one, and that it cannot be made to flow in the opposite direction without the expenditure

of energy, by a pump or other device.) Although the "second law," when presented in this form, may appear absurdly simple, yet its consequences are by no means easy to follow, and many of them are so hidden that much patient study is required to trace them out. Without going into the matter more deeply, we shall state that one of the many important consequences of this "second law" is, that it is impossible, by means of any reversible mechanical device or combination of devices, in which a working body is subjected to a cyclical change of temperature, to derive continuous mechanical effect from air or any other substance, by cooling it below the temperature of the coldest of the surrounding objects. We have stated this consequence in a rather ponderous way, because when we are criticising another fellow we always want to be quite exact in our own statements. The untechnical reader need not trouble to cipher out just what the foregoing statement means, provided he is willing to accept our assurance that Mr. Tripler's apparatus is the equivalent of the kind of apparatus there described, and that the thing he is trying to do is the very thing that is there declared to be impossible. He subjects a given mass of air to the following operations: Firstly, he cools it and compresses it, until it liquefies. Secondly, he allows the air thus liquefied to evaporate and expand in an engine. Thirdly, in the course of this process he claims to have gained a certain amount of mechanical energy, and he states that the mechanical energy so gained is obtained by the absorption of heat from the surrounding atmosphere, and the transformation of the heat so absorbed into work. That is, he claims that the mechanical energy that he gains is obtained by cooling a certain portion of the ambient air *below the temperature of the rest of the ambient air;* which is precisely what the second law of thermodynamics says cannot be done by such means as he employs.

In reply to these considerations it may be urged that all human knowledge is liable to additions and corrections, and it may be claimed that Mr. Tripler has discovered that the second law of thermodynamics is unsound, and that he has shown how it can be violated. Our rejoinder to this argument would be as follows:

1. The second law of thermodynamics has been subjected to the most searching tests, by many physicists and mathematicians of undeniable ability, and yet it has withstood all these tests perfectly. It has predicted many previously unknown facts which have afterwards been verified by direct observation, and it has never, heretofore, been found to be at variance with experience in the smallest particular.

2. We believe that Mr. Tripler is not thoroughly informed on the subject of thermodynamics, for the following reasons: (*a*) He speaks of the "absolute zero" as "Dewar's," whereas the fact is that Dewar has had nothing to do either with the theory of the absolute zero, or with the experimental determination of its position. The theory is due to Lord Kelvin, and the experimental determination of the position of the point is due to Kelvin and Joule. (*b*) He says that "we don't yet know just how cold the absolute cold really is . . . but Professor Dewar thinks it is about 461 degrees below zero, Fahrenheit." Now, this is literally correct, and yet it is hardly what a man would say, if he were aware that our uncertainty about the position of the absolute zero can hardly amount to a third of a degree. The language is that of a man whose knowledge of the theory comes from some popular lecture or article, rather than from a sound knowledge of what the absolute zero is, and how and by whom its position was determined. (*c*) On the last page of the article in question it is implied (presumably with Mr. Tripler's sanction) that the efficiency of a reversible cyclical heat engine may depend upon the nature of the working body, it being particularly intimated that air is superior, as a working body, to water and steam. Now this is one of those plausible looking things that further study shows is not so; and Carnot taught us, in the early part of the present century, that the efficiency of the engine does not depend in the least degree upon the nature of the working body, being the same whether that body is air or steam or ether or bisulphide of carbon, or anything else. (*d*) Except in the more advanced treatises, writers of books on heat engines and thermodynamics have seldom treated the "second law" carefully enough and fully and clearly enough to give the reader a good understanding of it. This is unfortunate, and it doubtless explains why so many otherwise capable inventors repeatedly try to do things that are opposed to this law. The "second law" ought to be popularized as the first one has been, so that such intelligent and capable men as Mr. Tripler might have an opportunity to inform themselves about it, without having to study

higher mathematics, and perhaps some foreign language also, to do so. A book is wanted on this subject, and if somebody doesn't write it pretty soon, we may be forced to write it ourselves.

Now, if it be admitted (1) that the "second law" of thermodynamics has been sorely tried and yet never before found wanting, and (2) that Mr. Tripler is probably not well informed concerning this "second law," then the probability that he has demonstrated the falsity of this law becomes very small, and the alternative probability, namely, the probability that his reputed production of ten gallons of liquid air from three is to be explained in some other way, becomes correspondingly greater.

It will be observed that we have adhered, in this discussion, strictly to the technical and scientific aspects of the problem, and that we have scorned to make use of the suggestion raised by our esteemed contemporary, the "American Machinist," which says that "Mr. Dickerson, Mr. Tripler's most trusted assistant, was compelled to acknowledge, at a recent meeting of the Franklin Institute, that the statement (about producing ten gallons of liquid air from three) was untrue." We trust that our forbearance in not raising this point will be appreciated by all concerned.

Another recent example of "magazine science" will be found in "The Century" for April of this year, under the heading, "Absolute Zero." The author of this article tries, at the outset, to give his readers an idea of the kinetic theory of gases—a theory about which he appears to have some very hazy ideas. He compares the molecules of a gas with a lot of little balls, in the following language: "Picture to your mind a room in which there are small balls all alike, each ball endowed with bitter hatred of all other balls of its own kind, and an intense desire to get as far from them as possible. The balls will assume positions equidistant from one another in every direction, and the outer ones will press against the walls of the room with all the force they may possess in their effort to get away from their kind. If more balls are forced into this room, all the balls must readjust their positions and come nearer to one another. The result of forcing them nearer together will be to produce a greater tendency to go farther apart, and greater pressure against the walls of the room. The balls represent molecules of gas—for example, oxygen. The gas presses against the walls of its retaining vessel *because of the repulsion between the molecules.*"

As the article here under examination has not attracted the same attention as the one in "McClure's," and as it does not hold out the same extraordinary possibilities in the way of producing power and otherwise revolutionizing things, we shall not need to discuss it at any great length. We cannot allow our author, however, to speak of molecules as "becoming accustomed to one another," or as being "endowed with bitter hatred," or as having "intense desires" to do things, without a passing expression of our contempt for all such puerile phrases. A magazine of the standing of "The Century" should not admit such wishy-washy language to its pages. Its readers are not children, and any man who would take any interest whatever in the "absolute zero," would be able to understand good straight English.

Passing now to the question of *accuracy*, we find that the passage quoted above contains a serious error of fact. "The gas presses against the walls of its retaining vessel," says our author, "*because of the repulsion between the molecules.*" Now, one of the most elementary teachings of the molecular theory is that this is not the case at all. In fact, the molecules of bodies never do repel one another, so far as we are aware, except possibly in the case of hydrogen. The evidence of such repulsion even in hydrogen is very weak indeed, and in all other bodies that have been investigated the molecules *attract* one another. The pressure that gases exert against the vessels containing them is due to the collisions of the flying molecules with the walls of those vessels. The intermolecular forces, instead of *causing* that pressure, actually tend to *diminish* it to a slight extent. A writer who would fall into an error as elementary and as gross as the one here signalized, has no business to write articles on these matters for the "instruction" of the public. We are not surprised, after noting this blunder almost at the outset, to find other meaningless or erroneous phrases later on. For example, on page 884, the article refers to the diminution of the electrical resistance of pure metals at low temperatures, and goes on to make the meaningless suggestion that "perhaps electrical waves traverse external space without loss of energy." If he means that a vacuum will allow of the passage of an electric *current* without resistance, he is writing arrant nonsense. If he means that perhaps waves of electrical *displacement* can traverse external space without resistance, he is only putting forth as his

own crude guess a proposition that has been established ever since Maxwell's electromagnetic theory of light was first accepted by physicists. Besides, what has temperature to do with space, anyhow? How can a vacuum be hot or cold?

The illustrations used in "The Century" article were made from photographs taken in Mr. Tripler's laboratory; and in the closing paragraph of the article we find that its author is more or less tinctured with Triplerism. He just nibbles at it a little bit, but is too wary to commit himself to it fully, as "McClure's" writer did. The paragraph is as follows: "Eager minds are striving to invent grander uses for the greater forces which the recent results place at our disposal, and some think they can forsee the day when the power stored in these abysses of cold will enable man to do that which is now looked upon as impossible, or at least chimerical."

"Magazine Science" is a wondrous thing.

CURRENT TOPICS.

Mrs. Frederic R. Honey.

The Dreyfus Case.

THE French have a proverb which recommends people to "wash their dirty linen at home." Self-respecting and patriotic Frenchmen must sincerely regret that modern newspaper methods have recently debarred their country from following this excellent advice. From whatever point of view the celebrated Dreyfus case is regarded, its public discussion has become for France a public scandal. Dreyfus may be an innocent man, unjustly condemned, either through carelessness, prejudice, or revenge, to a cruel fate. Or, in the face of strong evidence to the contrary, it is possible that he is guilty, and therefore deserving of a punishment to which, however, he was illegally condemned on the strength of secret evidence. In either case a tissue of trickery, deceit, and fraud has been revealed to the world; and the stains and rents of the national garments have been publicly displayed, instead of being sheltered in the decent privacy of the home laundry.

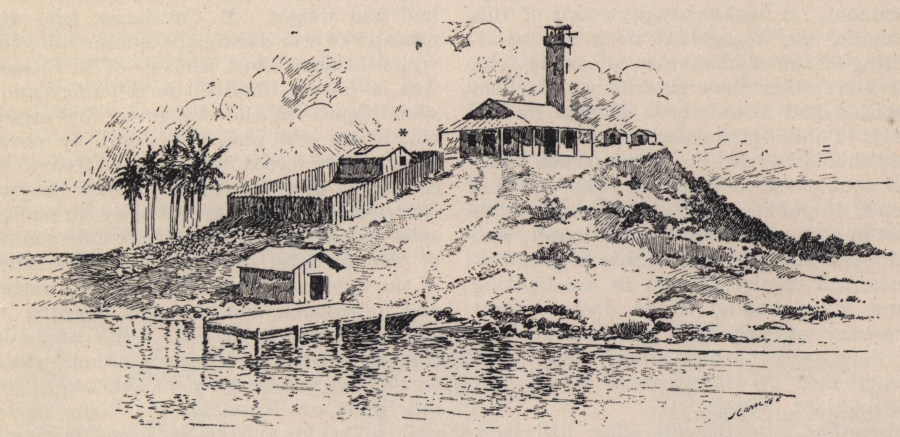
In October, 1894, a document was sent to the officials of the French secret service by a spy who had access to the rooms of the German embassy in Paris. This letter, or "bordereau," was written in French, and alluded to important information about military matters which had been imparted to Herr Schwarzkoppen, the German military attaché. These items of information could have been known only to officers of the French army. A French officer a traitor! betraying professional secrets to Germans! It seemed incredible.

Captain Alfred Dreyfus, a young officer of marked ability, was of Jewish birth. A strong anti-Jewish prejudice exists in Paris, and many were jealous of the success of one of the hated race. Suspicion was cast on the Jewish officer, whose handwriting was said to resemble that of the letter, or "bordereau." Specimens of his writing were procured and submitted to five experts in graphology. Of these, two detected a resemblance to the "bordereau," two denied that there was any likeness, and the fifth thought that the "bordereau" might have been written by Dreyfus in a disguised hand. Dreyfus was arrested, and accused of high treason. During the ten weeks of imprisonment which preceded his trial by court martial he was treated with great severity, as if his guilt were already proved. The prejudice that existed against him, even in the highest quarters, was very strong. General Mercier, then the minister of war and head of the army, declared three weeks before the court martial was held that Dreyfus was guilty.

The trial took place in part behind closed doors. Neither Dreyfus nor his counsel knew of the introduction of any testimony besides the now famous "bordereau"; and the world supposed that he was convicted on the evidence of that document alone. He was condemned to a disgraceful expulsion from the army, and to banishment with imprisonment for life. Dreyfus appealed to the military council, which is empowered to revise the decisions of courts martial. This court reaffirmed the verdict without examination; and on January 5, 1895, Dreyfus was publicly degraded. A special law was passed which provided for his solitary confinement on Devil's Island, a little spot of land off French Guiana, on the northeast coast of South America. To the last moment Dreyfus

protested his innocence of any crime against the country which he had loved and served faithfully. He charged his wife to devote her life and fortune to the discovery of the truth and the exposure of the traitor.

More than a year went by. In 1896, Colonel Picquart, an officer who believed in the guilt of Dreyfus, was appointed to a position in the information department of the army. He found among the papers in his charge grave reason to suspect that another officer, Count Ferdinand Walsin Esterhazy, was a spy in communication with the spies of the German and Italian governments. Investigations of his character and his antecedents confirmed these suspicions. Colonel Picquart also observed a close resemblance between the handwriting of Esterhazy and that of the "bordereau"; and he



DEVIL'S ISLAND, SHOWING DREYFUS' HUT *, WITH SURROUNDING STOCKADE, THE QUARTERS OF HIS GUARDS, AND THE WATCH TOWER ARMED WITH A HOTCHKISS GUN.

began to fear that an outrage of justice had been committed. He urged a revision of the Dreyfus trial in the interests of truth and honor. But Esterhazy had powerful friends; Picquart's investigations were suddenly stopped, and he himself was sent to a distant part of France, and thence to Africa. His successor in the information department was Colonel Henry, a man of strong anti-Jewish tendencies. General Mercier, the minister of war, had been succeeded by General Billot, who was dissatisfied with the appearance of the Dreyfus affair at the stage it had reached. To quiet his suspicions, Col. Henry produced a letter which he declared to be part of the secret evidence against Dreyfus. It appeared to be from the German to the Italian military attaché in Paris, and in it Dreyfus was specifically named as a spy.

The discoveries, with regard to Esterhazy, had not been made public, yet uneasiness was felt by all concerned in the conspiracy. The possessor of a guilty secret should be silent as the grave if he wishes to protect himself from discovery. His greatest danger lies in the restlessness which makes him endeavor to strengthen his position by drawing attention to the points which—in his opinion—are in his favor. Dreyfus, in his miserable captivity, would not have been forgotten by his wife and kindred; but they might have been unable to produce important evidence on his behalf if certain officials of the information department had known how to hold their tongues. In September, 1896, in order the more certainly to divert suspicion from Esterhazy, these officials procured the publication in the "Eclair," a Paris newspaper, of an article which stated that the "bordereau" had not been the only evidence produced against Dreyfus at his trial, as was supposed to be the case. Other documents had been secretly supplied to the officers who composed the court martial; but they had not been shown, as the French military code of justice requires, to the prisoner and to his counsel. These documents were announced to have been of such a character that in the interest of the nation the department had thought it unsafe to make them public. Thoughtful people were shocked at this open acknowledgment of illegal action in connection with Dreyfus, and the belief that he had been the victim

of a conspiracy gained ground. Madame Dreyfus was quick to take advantage of the admitted breach of law, and appealed for revision of her husband's sentence. Her appeal was refused on the ground that the government itself had no right to discuss a verdict regularly given. Lovers of justice, in France and out of France, protested that, if a verdict had been procured by means of a breach of law, it was not a "verdict regularly given."

But the article in the "Eclair" indirectly rendered another service to the friends of Dreyfus. It published the text of the "bordereau," of which Dreyfus was supposed to be the writer. A pamphlet appeared in a few days which disputed the accuracy of this copy of the "bordereau." Thereupon the "Matin," another Paris newspaper, published a photographic facsimile of the original document. A banker bought a copy of this facsimile, and recognized in it the handwriting of one of his former customers, who was none other than Esterhazy, on whom suspicion had already been thrown by Picquart. Public opinion demanded that Esterhazy should be tried by court martial. The trial took place in January, 1898, and was opened in public; but the testimony of the most important witnesses—of Picquart, who had been sent for from Tunis to give evidence, and of the experts in handwriting —was given behind closed doors. Count Esterhazy was acquitted, yet the suspicions of those who had doubted him were strengthened by the secrecy which had characterized his trial.

Meantime, the Dreyfus affair had been discussed by the Chamber of Deputies. The prime minister and the minister of war declared that they had positive proof of his guilt, and on this declaration the Chamber upheld the verdict of 1894, and refused to grant revision.

The famous novelist, Emile Zola, in common with many other Frenchmen of the highest character, was roused to indignation by the partiality shown in connection with the trials of Dreyfus and of Esterhazy. Zola wrote an open letter to the president of the French Republic, denouncing the officials of the war department who had been responsible for the conduct of the two cases, and accusing them of deliberate and intentional injustice. Zola was prosecuted, and, after a stormy trial in which his witnesses were repeatedly silenced, he was condemned to a year's imprisonment. He appealed to the Supreme Court of France, the "Court of Cassation," and the decree against him was annulled on a technicality. He was again prosecuted, but not appearing in court at the appointed time he was condemned by default, and quitted the country.

Throughout the year 1898 the question of the revision of the sentence of Dreyfus continually agitated Paris. The suspicion, the fear that he had been the victim of a conspiracy in the highest quarters, became almost a certainty. Picquart, the ex-official of the information department, was not a friend of Dreyfus; he had no personal connection with him; but with a love of truth and justice, and a noble disregard of his own interest, he would not let the matter rest. In July, 1898, he declared that an important document, used in the trial of Dreyfus, had "all the characteristics of a forgery." He was arrested and imprisoned; but his words had had weight. M. Cavaignac, who was minister of war during the summer of 1898, while the short-lived ministry of M. Brisson was in power, obtained secret information with regard to the document, by means which are still unknown; and by cross-examination forced from Colonel Henry the confession that the letter in which Dreyfus was named as having dealings with foreign spies was forged by himself, in the summer of 1896, in order to convince General Billot of the convict's guilt. Henry was arrested and imprisoned, and the next morning he was found dead in his cell. Who can doubt that he carried to his grave secrets which would have ruined many a reputation? The conclusion was inevitable that the evidence against Dreyfus must indeed have been weak when it was necessary to have recourse to forgery in order to keep him in the captivity to which he had been condemned by cruelty and fraud.

Henry's death took place on September 1, and added fuel to the flame which already raged. The struggle between the advocates and the opponents of revision became intensified. The position of the former was greatly strengthened; the latter exhausted all their ingenuity to prevent or delay the action, or to change the character of the court by which the sentence should be revised. Noble men have followed in the steps of Picquart, have sacrificed their careers, braved the insults of the mob (who idolize the army and feel that its prestige is threatened), and have publicly espoused the cause of truth and justice. If France must blush for the revelations of trickery and dishonor in connection with the Dreyfus case, she should also be proud of the

men who, without noise or clamor, have stood for upright dealing. They have set their faces like a flint, and declare that justice shall be done—not for a friend or a brother, but for the son of an alien race; for a fellow citizen who claims to have suffered injury at the hands of France. For the sake of France, whose fair name has been aspersed, they say that the wrong must be repaired.

At the present time the case of Dreyfus is being considered by the Court of Cassation, a body of noble, upright, and honorable men who care nothing for public favor and have no guilt to hide. But how little can be done for this poor prisoner if he *should* be declared to be innocent! None can give back to him the bitter, wasted years, the lost career; none can restore the broken health, the shattered nerves; none can blot out the memories of anguish and despair which threaten to overshadow the remainder of his mortal life!

THE KITCHEN FIRE.

Mrs. Henry Esmond.

THE PRINCIPLES UPON WHICH A STOVE IS CONSTRUCTED—THE MEANING OF DRAFT—HOW TO LAY THE FIRE—OPERATION OF THE DAMPERS.

THERE are certain principles connected with the building of a fire that should be understood by every one; this, not only because the subject itself is interesting, but because there is at least *one* fire in every house, and if that—the kitchen fire—fails on occasion to burn properly, there are chances of a good meal being spoiled, and the general temper of the "house" unpleasantly ruffled. Especially, therefore, does it behoove the good housewife to know all there is to know about the subject, that she may be in a position to wisely coax the sometimes refractory stove, and so maintain her very excellent reputation as a cook.

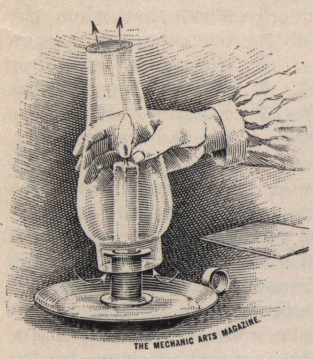


FIG. 1.

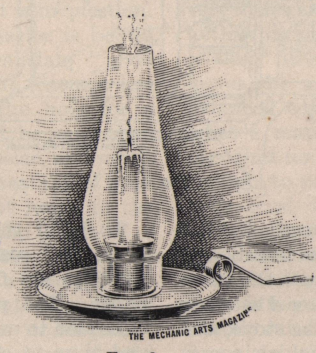


FIG. 2.

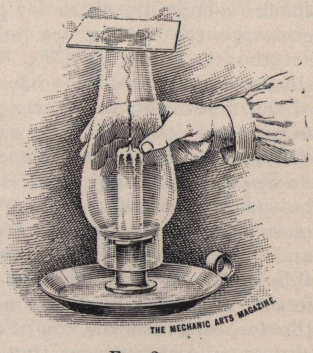


FIG. 3.

To make a fire we must have something to burn—either wood, coal, gas, or oil; in short, we must have *fuel*, which means anything for making a fire with. We all know that air is necessary to keep a fire burning, and that we must be able to regulate the supply of air according to the amount of heat required. For convenience, our kitchen fires are usually enclosed in an iron box, called a *stove*. As the conditions for making a fire are the same in all enclosed spaces, we will use, for the sake of illustration, a candle, and a lamp chimney to enclose it. Light the candle and stand it on the table; hold the chimney over it a few inches above the table, as in Fig. 1; the candle burns freely. If, now, the hand is held over the opening at the top of the chimney, there will be noticed an upward current of decidedly hot air, while at the lower opening it can be shown that the air is just as cool as that in the room; this shows that hot air rises. If the chimney is set down on the table, as in Fig. 2, the flame will soon go out, though there is still the opening at the top; this shows that where there is a fire in an enclosed space the air to keep it burning goes in at the lower opening, and that the heated air and the products of

combustion rise and pass out at the upper opening. Now, if we hold the chimney over the candle, as in Fig. 1, and then, while the candle is burning, place a sheet of glass on the top of the chimney, as in Fig. 3, the flame will go out in a very short time. By this we learn that it is necessary to have free *circulation* of air through the flame, otherwise it will go out; in other words, we must have "good draft." The word *draft* means the act of drawing, or pulling, and is used here because, when heated air rises, cold air is forcibly drawn, pulled, or sucked in to take its place.

We often hear the expression "the stove doesn't draw well," or "the chimney hasn't a good draft," which mean that there is some obstruction, which either prevents the air from going *into* the stove freely, or else prevents it from passing *out* freely. A coal stove consists, as shown in Fig. 4, of a large iron box, with a space at one end lined on three sides with firebrick *b*, and the front and bottom of which consists of iron bars with openings between. This space is called the *firebox*, because in it the fire is built; the air goes into the firebox at either the bottom or side, or both. Outside of the firebox on the front of the stove is a slide *s*, called the *front damper*, which may be opened or closed as more or less air is needed. Directly behind and close to the firebox is another iron box *c*; this is the oven, and it is set into the stove in such a way that there is a space *d* between the top of it and the top of the stove, and also on all sides except that which comes directly next to the firebox. In the chimney, at *g*, is an opening controlled by another slide, called the *chimney damper*, which controls the opening into the pipe connecting the stove with the outer air. This chimney damper and the front damper are the only ones that are absolutely necessary, so far as the fire is concerned, but we find here still another, *h*, called the *oven damper*, the use of which will now be explained.

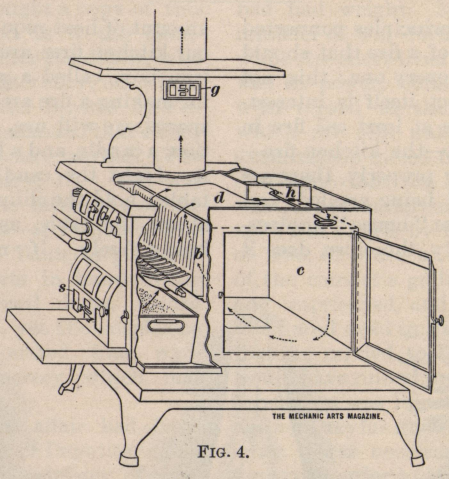


FIG. 4.

If we light a piece of paper and place it in the firebox, we notice that when the oven damper *h* is open the flame is drawn across the top of the oven, direct to the chimney. Closing the oven damper, as in the figure, we find that the opening leading to the chimney is thereby closed, and that the flame is now drawn across the top of the oven, down the opening at the end, under the oven and up behind it, finally reaching the chimney; we thus understand that by the closing of this oven damper the heated air is compelled to go around the oven before reaching the chimney, and that in this way the oven is heated. The arrangement of these dampers differs in different cooking stoves, but the principle is always the same. There *must* be a lower or front damper to control the supply of fresh air, and there *must* be a chimney damper to control the escape of the smoke, gases, etc., and, in order to heat the oven, it is necessary to compel the heated air to pass around the oven on its way to the chimney, and therefore there must be an oven damper.

When the fire is first lighted, all the dampers should be opened, so as to allow plenty of fresh air to go in, and all the smoke, etc., to get out freely, it being understood that when the oven damper is open the smoke has free and direct access to the chimney. When the fire is burning freely, the oven damper is the first closed, so that the oven may be heated.

To build the fire, paper, soft wood, hard wood, and coal are generally used, though shavings are frequently substituted for the paper. The paper is put in first, and is crumpled to make more air spaces within it, and thus to cause it to burn more freely; next comes the soft wood, which, having a higher kindling point than the paper, is heated to the necessary degree by the burning paper; this soft wood has coarse, loosely packed fibers, the spaces being filled with air when the wood is dry; over the soft wood should be placed some hard wood; this, having finer fibers, more closely packed, contains less air, and so does not burn as easily as the soft wood; the coal comes on top of all, and, having a higher kindling point than either kind of wood, must be heated to the kindling point by their burning.

The wood must be arranged slightly crosswise, that the air may circulate around it, care being taken at the same time to keep the ends close to the sides of the firebox, that the coal may not drop through to the grate unburned.

When the coal has become well kindled, the oven and the chimney damper should be closed more or less, according to the heat required. The chimney damper is so arranged that it cannot be entirely closed; if it could, ignorant or careless persons might close it, and then the fire would not burn, or, if already burning, the poisonous gases from it would escape into the room, to the danger of the occupants of the house, especially if they are sleeping. After the fire has been burning for some time, the ashes collect at the bottom of the grate, and must be poked or shaken out, otherwise the air will not reach the hot coals, and soon the fire will go out.

GOOD WORK.

GOOD work does not necessarily mean work of great accuracy. For instance, it is possible for a wooden shed to be a good shed, well put up, strong, serviceable, and sightly, and yet no single dimension in it be exact to any drawing or to any preconceived idea of what it was to be; here, an inch or so either way is of no importance whatever. So in the machine shop a thousandth of an inch more or less in the diameter of a 6-foot belt pulley is practically nothing, that is, it is not worth consideration; on the other hand, the same amount may be a good deal on the diameter of a 3-inch shaft, when a forcing fit is in question. As a general rule, serious disaster is bound to follow an attempt to translate "good work" into "close fit." The attempt has proved before today that the hole for a 1-inch spindle to run in must be *more* than 1 inch in diameter, or it will seize, and much damage be done. The true meaning of good work has often been brought home to the too accurate workman by the parts of a machine seizing in this manner. The good workman should know when a specially fine fit is necessary, but he should also know when and how to render it unnecessary. These are points that the designer should bear in mind, too, no matter *what* he is designer of.

On the majority of machines, great expenditure of skilled labor is wasted, and is evidence of bad practice. Undue anxiety to use the best possible material may also be bad practice. It generally pays better in the long run to use ordinary material—good, dependable, commercial material; true, it may be necessary to employ more of it, but even then it will pay, not only because the first cost is less, but because, in case repairs are necessary, the commercial material can be had at once—taken from stock, probably—whereas the special, high-grade material will have to be made and will cost very dear in delays. In many cases, the extra weight of the cheaper material may be a virtue, and it is certainly *not* good work to put in a great weight of costly stuff when the cheaper material possesses a margin of strength beyond any other part of the same structure.

Now, there are machines upon which a great expenditure of time and skilled labor is not wasted. Two watches of the same make, that are apparently identical, will have very different values, according to the skill with which they are made, and the fineness of their finish. Whether or not the watch leaves the workman's hands with perfectly balanced corrections may seem to be somewhat a matter of chance, but we may be sure that no badly made watch will run well enough to receive a high certificate. Here, with good work attempted throughout, a little extra and expensive final finish may pay handsomely.

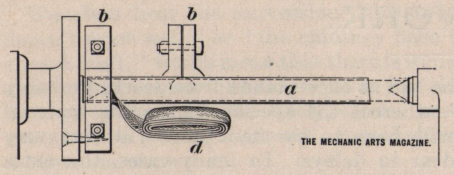
In dealing with artisans, the great difficulty is to get a man for a special job who is exactly suitable for it. For instance, a really first-class cabinet- or pattern-maker may be quite useless for a rough carpentry job, because he has acquired certain habits and has become by nature too accurate to make a paying job of the rough timber shed. Again, the man accustomed to rough work is often incapable of comprehending what great accuracy means where it is really needed. There is an old saying, "You cannot make a silk purse out of a sow's ear." But it is poor policy to degrade the sow's ear. There is far too much of the silk purse about some men. Good work always represents the *correct* degree of accuracy.

GOOD SCHEMES

TO HOLD A THIN TUBE IN A LATHE.

W. H. D. Bogue, Chicago, Ill.

With the hope of adding to the interest of the Good Schemes department, I enclose a sketch of a method of holding thin tubing in a lathe, that I think will be of use to some. Referring to the drawing, *a* is a very

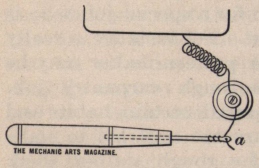


thin tube, upon one end of which it is desired to cut a screw thread; wrap the other end of the tube with tape *d* and grip in either a wooden or a metal chuck *b*; it will be found that by this means a perfectly secure hold is obtained. The other day I was watching a lathe hand at work on some bicycle necks, and I noticed he had a hard time keeping the tube from slipping; at my suggestion he tried the above scheme, and said it was just the thing, and that he had no more trouble. So I pass it on, for the benefit of others.

NEEDLE FOR ELECTRICAL WORK.

R. L. Wheeler, Peoria, Ill.

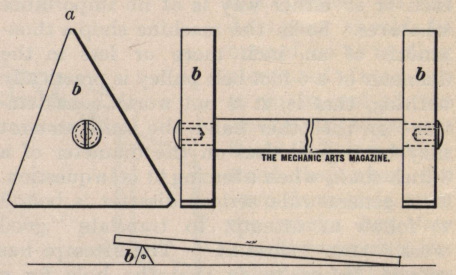
Sometimes in electrical work, such as assembling meters, etc., it is very difficult to connect the fine wire that leads the coil to some other attachment, the connection being made by a screw. A pair of extra-long tweezers may seem the proper thing, but where there is little room to work they will often slip off. The accompanying sketch shows what I have been using for the past few months with most satisfactory results. Take a piece of soft-iron wire about $\frac{3}{64}$ of an inch in diameter and $1\frac{3}{4}$ inches long; flatten one end, as at *a* in the sketch, and make a hole in it large enough to receive the wire easily, and furnish the other end with a wooden handle. With this tool it is possible to reach any place that a screwdriver can touch, and to hold the wire firmly. After the wire has been secured in the desired position, the needle is loosened by simply untwisting.



SELF-ADJUSTING DRAWING-BOARD REST.

F. L. Nichols, Baltimore, Md.

Wishing, as no doubt other readers of The Mechanic Arts Magazine have, for something better than the usual blocks for inclining my drawing board with, I hit upon the following good scheme: I cut out two triangular blocks *b* of hard wood about 1 inch thick, drilled a hole in each, and slipped them on the ends of a wrought-iron rod a trifle shorter than the length of my board, as shown in the enclosed sketch. By leaving one of the blocks free to rotate on the end



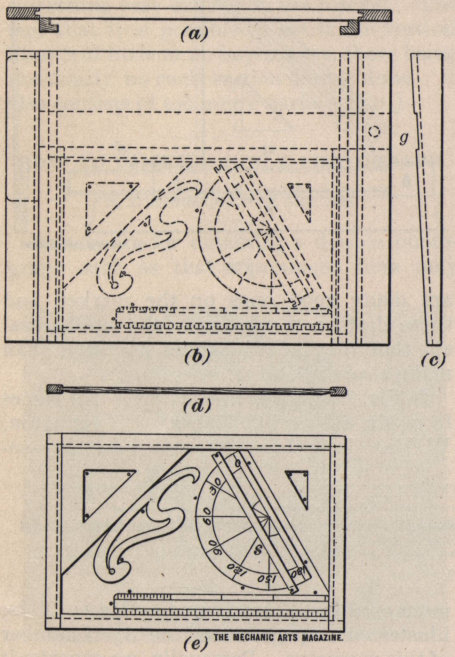
of the rod, the device becomes self-adjusting, and accommodates itself to any twist in the surface of the board or table, and, by making the sides of the blocks of different lengths, the inclination of the board can be varied at will. The sides of the blocks that I use are $4\frac{1}{4}$ inches, $5\frac{1}{8}$ inches, and $5\frac{5}{8}$ inches, respectively. By cutting off the corners as at *a*, the blocks are prevented from marking the board, but by leaving the edges of the corner surfaces sharp, the board is prevented from slipping.

A DRAWING-BOARD OUTFIT.

O. F. Paul Spitzel, Orange, N. J.

When I got my drawing-board, etc., at the commencement of my studies with The International Correspondence Schools, I was at a loss to know how to keep everything together properly, until I invented the scheme illustrated herewith. At (*a*) is shown the front of the drawing board, at (*b*) a plan, and at (*c*) an end view. I first cut

out a groove in each runner, as at g in Fig. (c); this takes the blade of the T square as shown; then I made a tray drawer, as shown at (d) and (e), to slide in under the board and to butt up against the blade of the T square. In this tray I pack away two triangles, a curve, a protractor, and a 12-inch

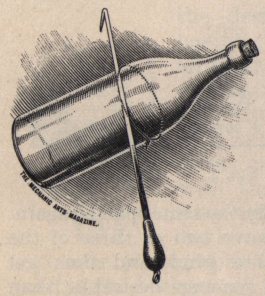


scale; s is a piece of clock spring, slotted at the ends so as to fit under the heads of two drawing pins, and thus keep the protractor flat on the bottom of the tray.

IMPROMPTU JAR FOR BATTERY.

Reader.

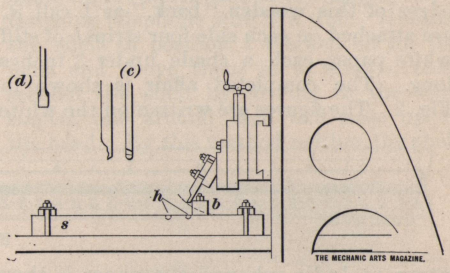
Some time ago I had the misfortune to break the glass jar belonging to the battery that rings the house bell. Happening to look around, I saw an empty glass bottle almost the exact diameter of the broken jar, and I made up my mind to cut the neck off the bottle and so save the cost of a new jar. To do this, and not having a diamond or other form of glass cutter, I tied a piece of copper wire around the bottle at the place where I wanted to cut it, and started the cut with a file; then I slowly ran a red-hot poker around the bottle, using the wire as a guide, as shown in the drawing. This cut the neck off perfectly clean, and gave me a suitable jar at the cost of but a few minutes' labor.



PLANING SHORT KEYWAYS.

Geo. F. Meyer, Milwaukee, Wis.

In the course of shop work it is sometimes necessary to cut a keyway the length of which is less than the shortest possible stroke of the planer on which the job must be done. The sketch below shows how, with very little trouble, this may be done. The shaft s is first drilled for the ends of the keyway, with holes h, as usual; it is then clamped to the planer platen, and a block b



is clamped on top of the shaft, a little back of one of the end holes h; this block must be high enough to prevent the tool from getting over the top of it, the necessary height depending on the amount of travel of the platen. With this arrangement, during the return of the platen, the cutting tool is tilted up away from the shaft and starts to cut only when block b allows it to fall back into position at the commencement of the keyway. The holes h are, of course, of a diameter equal to the width of the keyway, and are drilled to the required depth with the usual tit drill. It is always best to plane a flat on the top of the shaft; this can be done by means of the cross-feed, using a tool like that shown at (d). A good form of keyway cutting tool is shown at (c).

ATTACHMENT FOR STEEL SCALES.

Anonymous.

When I started in at the drafting board, some years ago, I made up my mind that the best kind of scale was one made of steel. The advantages of a steel scale over a wooden

one are that it does not shrink or warp, and that the graduation lines have a distinct depth. But I soon found that the steel scale has two serious disadvantages: It is difficult to pick up (being slippery and the ridge for handling being small) and the graduation lines and figures are in some lights very difficult to see. To overcome these difficulties, I fitted mine up in the manner shown in the accompanying sketches. Fig. 1 is an end view, just about full size; in it the shape and proportions of the scale itself are clearly shown. The attachment consists of a strip *a* of hard wood, the same length as the scale, and grooved on the under side so as to slide on to the ridge as shown. To the under edges of this wooden "back," as I call it, are attached on each side four strips *b* of stiff white paper, each a shade under 3 inches long. The completed affair is shown in Fig. 2. The figures are written on the white

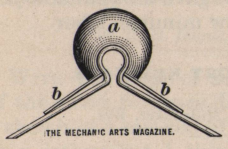


FIG. 1.

paper in India ink, and the paper is then coated with clear white shellac. On my scale, which, by the way, I have used for 8 years and is still in excellent condition, I graduated and figured the paper for full-size, half-size, quarter, and eighth. The figures are perfectly clear, and stand out in great shape as compared with those on the steel, and the wooden back makes the scale as convenient and easy to pick up and handle as an all-wooden one. I should add that the reason the paper strips are made in sections 3 inches long is that I found by experiment that if a single strip the full length of the scale is used, it will buckle up in damp weather, and shrink so much in dry weather as to pull itself off the wooden back. When made in 3-inch lengths, the paper strips always lie flat; the fact that mine have stayed on for 8 years is proof that they are secure.

TWO MORE SECTION LINERS.

The two devices illustrated here are the best of numerous section-lining schemes sent in during the past month as contributions to these columns. There is nothing new about them or about any others received, but they will suffice to bring to a close the little controversy that Mr. Palmedo's article on patent-office drafting has caused. By this we mean that no other section liners will be illustrated or described here; there

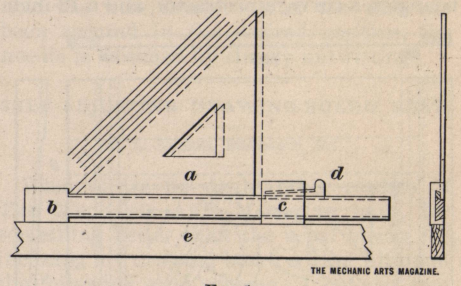


FIG. 1.

are many good ones on the market, and those draftsmen who wish the mechanical aid that they afford cannot do better than make a careful choice.

In Fig. 1 is represented a device that comes from Mr. Edward C. Fisher, of Huntington, W. Va. It is claimed that it is an improvement on the one contributed by Harry Bible, illustrated on page 129 of the April number of this magazine. Personally, we consider it inferior, for the reason that there are *three* pieces instead of *one*, and because if piece *c* were accidentally loosened, it would be difficult to set it to exactly the same spacing again. We would rather have two or three of the simple non-adjustable kind, and thus get all the variety of spacings desirable, than one of this construction and be continually having trouble with the setting. On general principles, too, a device consisting of one

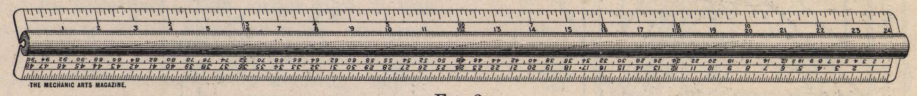


FIG. 2.

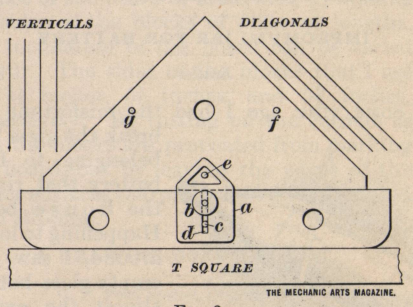


FIG. 2.

simple piece is better than a device for the same purpose made of three pieces.

The scheme shown in Fig. 2 was sent in by Mr. William Pittman, of Jerseyville, Ill. Though this, if nicely made, would doubtless do good work, it would be decidedly expensive to make, and if we mistake not there is something very similar on the market. The fact that it is possible to set it for vertical lines is of little or no importance, there being practically no such section lining done. It also consists of too many parts.—[ED.]

HOW TO TAKE A DOUBLE PHOTOGRAPH.

S. J. Routledge, Pratt City, Ala.

DIRECTIONS for obtaining a double photograph such as that reproduced here may

FIG. 1. A DOUBLE PHOTOGRAPH.

be of interest to some of the amateur photographers that read THE MECHANIC ARTS MAGAZINE.

Have the tinsmith make a cap to fit tightly over the hood of the lens, and have barely half of the bottom of the cap cut out, as shown in Fig. 2. Paint the inside of this cap black. To make a double picture, focus for the desired view as usual, having the subjects you wish to appear twice in the same picture well to one side of the center line of the picture as it appears on the ground glass; put on the half cap with the diameter vertical; draw the slide of the plate-holder and expose; this exposure photographs the subjects and the half of the background that is behind them. Without moving or in any way disturbing the camera, have the subjects cross over to the other side and make a second exposure.

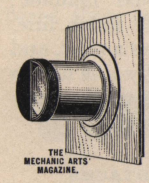


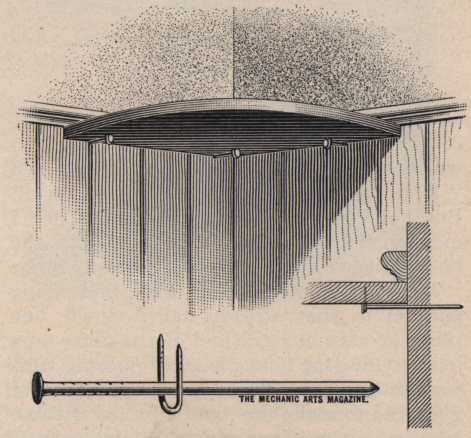
FIG. 2.

On developing, it will be found that the two exposures of the background have blended so perfectly about the vertical center line that the picture seems to have been taken with but a single exposure, while the subjects appear on both sides of the picture. In the photograph reproduced here we have the same boys sitting on both ends of the bench at one and the same time.

TO PUT UP A SHELF.

Otis, Cleveland, Ohio.

AS A DABBLER in photography, I had occasion the other day to put up a small shelf in the corner of my dark room. I had the shelf, but no brackets or other means of supporting it or securing it in place. Finally, I hit on the scheme shown in the illustrations herewith, using, in conjunction with three wire nails, three staples such as are employed for fastening telephone wire to a wall. Holding the shelf in position, I marked off for the nails and drove them in as shown, then secured the shelf by driving in the wire staples, one around each nail close up to the head. By this method neither the shelf



nor the wall is at all disfigured; and the shelf is very secure, yet can be taken down easily and without disfiguring the wall.

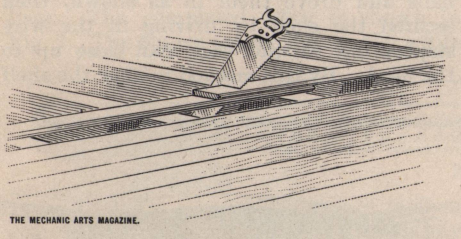
SAWING FLOORING.

C. Francis Jenkins.

WHEN I went to serve an apprenticeship as a carpenter, one of the things I learned was to lay flooring. This isn't remarkable, for every boy would be taught that, but I noticed that breaking joints required considerable skill and dexterity in order that the

joints might not be conspicuous by gaping cracks. As usually done, the flooring is marked with a knife blade along the blade of a try-square very carefully held in place. The sawing is done with a fine saw (backed, frequently), and when these three—the knife, the square, and the saw—are used skilfully, and the flooring is run straight, and sawed under, a very fair joint is the result. It is not a rapid method, by any means, and it takes a good carpenter to keep out of the way of but one man laying and blind nailing.

Being, by nature, partial to "short cuts," which, translated, should mean the quickest way to do a thing well, I surprised my "boss" one Monday morning by offering to work the week out without pay if I could not saw flooring, making good joints, as fast as two men could nail it down, and as a side remark said I would use no scratch to work by. I had practiced in secret and knew I could do it. As the floor we were laying



was not a too particular job, he jokingly told "John" to "give the boy a chance to try." But I did it, much to their surprise, for I more than kept out of the way of both the boss's helpers. And this is how it was done:

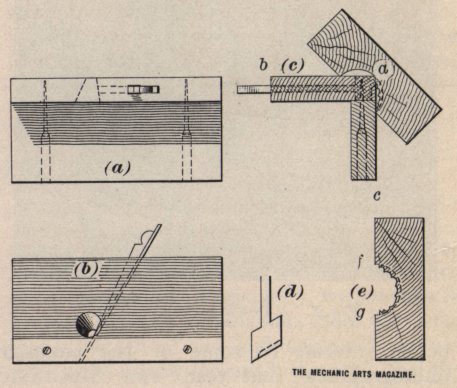
Two pieces of flooring were laid along parallel to that already nailed down, one piece overlapping the end of the other on a joist. Grasping both pieces of flooring with my left hand, the thumb at the point where I wanted to make the joint, I pulled the two pieces into position, with the joint a little past the joist, and *sawed through both at the same time*, using an eight- or nine-tooth saw. Of a consequence, when one piece was laid and the other butted up against it, the joint was all that could be desired. And the rapidity with which flooring can be laid by this method is a revelation to one accustomed only to the old method of knife joints.

The finest flooring can be sawed in this manner successfully, as also, with a little care, molding and other small stuff, following the same general plan of sawing through the two pieces at the same time while they are held in practically the positions they will finally occupy. The ugly slants in circular stair frames, in hip roofs, and the like can also be successfully managed in this way, and with great expedition. It is a good scheme, well worth adopting, and will be found to save not only time, but temper and material. It is the pleasure a man feels in using little schemes like this that makes his work worth doing.

A CORE-BOX PLANER.

W. A. Clough, Carthage, N. Y.

I WILL TRY to help out some of my brother patternmakers by describing a core-box planer that I have found of great assistance. Take an 8-inch "rabbet" plane and screw on to it, in the manner shown at (*a*) and (*b*), a 1-inch board of hard wood, making the width 1 inch less than the height of the



plane, so that the distance *a c* is equal to *a b*, and see that the angle *b a c* is exactly a right angle. Grind the planer blade to the dotted shape, as at (*d*), and so that the cutting edge is about ¼ inch wide. Mark out the semicircle for the core as shown at (*e*), and gouge out roughly in the usual manner; then trim the edges *f* and *g* to finish line, just far enough to give the plane a start, and do the rest with the planer. By this means a perfect semicircle is obtained without any difficulty, and much time is saved.

SUBSTITUTE FOR THUMBTACKS.

IF, INSTEAD of using thumbtacks, draftsmen would fasten paper to board with small copper tacks, they would be relieved of the annoyance of having **T** square and triangles constantly bumping up against the projecting heads. This scheme is better than it looks.

TRADE NOTES

IMPROVEMENTS IN BICYCLES.

THE ILLUSTRATIONS on this page represent some of the most striking improvements that have been made in the 1899 model of the Cleveland bicycle, manufactured by H. A. Lozier & Co., of Cleveland, Ohio. As enumerated in the makers' catalogue, the radical novelties include the Burwell combination ball-and-roller bearing; an entirely new method of anchoring the spokes in the hubs; a modified handle bar; bearings with lessened friction; modifications in the front and the rear forks; an improved crank-yoke; heavier tubing; fuller frame and fork reinforcements; a larger frame head; and refinements on the hollow axles.

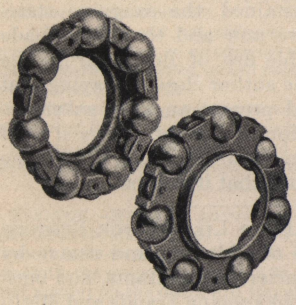


FIG. 1.

Perhaps the most noteworthy of these improvements is the ball-and-roller bearing; this is shown in Fig. 1, and deserves to be thoroughly understood, because the average cyclist has come to believe something that is not true, namely, that in the ordinary ball bearing there is no sliding friction, and that, therefore, it is quite impossible to improve upon it. Now, when the balls in an ordinary bearing move as they do, all in one direction, it must be remembered that, as related to one another, the

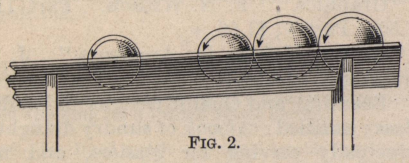


FIG. 2.

rear surface of every ball is moving in an opposite direction to the front surface of the ball behind it, and that there is a resultant of just so much sliding friction, due to this rubbing of the balls against one another. To help the reader to fully appreciate the significance of this, we show, in Fig. 2, part of a bowling-alley ball-way, down which the balls are returned to the bowlers. It is easy enough for one of these balls to roll down hill by itself, but things go much less merrily when several of the balls come in contact. Of the three shown touching, it will be seen that the middle one has two other balls to rub and grind against, the result being that these three soon come to a standstill, while the loose ball shoots ahead and races for home. In the Burwell ball-and-roller bearing there is a polished steel roller between each pair of balls, so that the surface motion of ball and roller is continuous, the only sliding friction being that due to the very slow and slight rubbing of the tiny pins upon which the rollers are carried. So far as it is mechanically possible to make it, therefore, this bearing is frictionless. The gain in easy running is positive, and a bearing

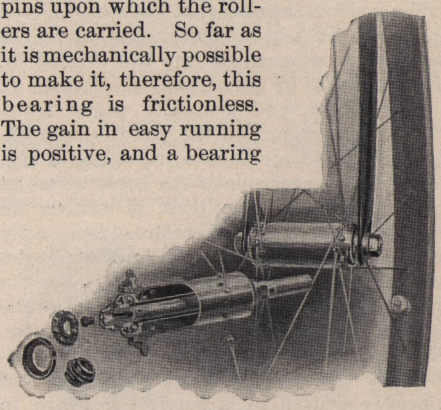


FIG. 3.

thus fitted will run equally well in either the vertical or the horizontal position, whereas in the ordinary ball bearing the hub spins longer when vertical, because in that position the balls are wider apart and less subject to friction. But the ball-and-roller bearing possesses incidental advantages that do not at once reveal themselves. One of the annoying features of bicycle bearings is the constant rattling noise caused by the balls as they rise over the crest of the cone and drop with a ceaseless clatter one on top of the other; now, while this is going on, the other balls are bunched in close company underneath, and for a moment of time have to bear more than their share of the pedal pressure, involving friction and loss of power.

In the ball-and-roller bearing, not only is the disagreeable rattle stopped, but the pressure is evenly distributed around the cone.

Next in importance is the new direct spoke, illustrated in Fig. 3. The hub end of each spoke terminates in a compressed-steel ball about ¼ inch in diameter, and the hub is drilled to receive the spokes direct. There is an extension on one side of the spoke ball that makes it impossible for the spoke to turn or to come out, except when brought vertical to the hub; in the latter position it is at once removable. To provide for this improvement the hubs are made slightly larger than before, thus gaining in strength and making the general appearance more handsome.

BOOKS AND CATALOGUES.

LIQUID AIR AND THE LIQUEFACTION OF GASES—THEORY, HISTORY, BIOGRAPHY, PRACTICAL APPLICATIONS, MANUFACTURE. By T. O'Connor Sloane, Ph. D. Published by Norman W. Henley & Co., New York. Price, $2.50.

The general interest that has been stirred up by accounts in the daily press, as well as in various magazines, of the wonderful achievements by Mr. Chas. E. Tripler in liquefying air, and generally vague statements with regard to the possible applications of liquid air in the industrial world, makes the appearance of the book before us most opportune. The book is written for the layman, and therefore necessarily reaches back to fundamental laws of physics and chemistry in preparing the reader for the understanding of the theory of the liquefaction of gases, and air in particular. These preparatory chapters fill nearly one-third of the book, and are as clearly and concisely written as is possible, perhaps, in treating such a subject; naturally they are not, and are not meant to be, very exhaustive, and reading them may be likened to a post-haste journey through a vast country, with a guide by your side, directing attention to the most important points. The journey is delightful; in other words, the subject is presented in by no means a dry manner, and affords pleasant reading. The next chapter contains a historical account of the development in the art of liquefying gases, from the early experiments to the latest methods, and gives incidentally the biographies of Faraday, Gretel Carlletet, Wroblewski, Olszewski, Dewar, and Charles Tripler as the most eminent workers in the field. Clear descriptions of the Linde apparatus and the Hampson apparatus are given, while that employed by Tripler is not so liberally described, but left somewhat wrapped up in mystery so far as the "liquefier" and the "valve" are concerned. This is to be regretted, as nothing is more conducive to disappointment to a reader seeking information than "undivulged" details of apparatus. Chapter XVI is an enumeration and illustrated description of the various startling experiments made by Mr. Tripler, and already familiar to many through the magazines. The closing portion of the book treats on some of the applications of liquid air, and here the reader is again somewhat disappointed, as he neither finds refuted nor sustained the sanguine statements that have now and then been made as to the possible use of liquid air in the industries. The author closes in saying that liquid air would present an ideal substance for the production of energy, *if only it could be produced cheaply enough.* And there's the rub. Let us hope that it will be.

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NEW BOOKS OF INTEREST.

Any of which can be obtained from The Technical Supply Co., Scranton, Pa.

"Text Book of Sound." E. Catchpool. $1.40.

"Navigation and Nautical Astronomy." W. R. Martin. $6.00.

"Elements of Physical Chemistry." J. L. R. Morgan. $2.00.

"Text Book of Physics." Vol. II. J. H. Poynting. $3.00.

"Graphics." F. N. Willson. Part III, $1.50. Part V, $1.00.

"Cabinet-Making for Amateurs." J. P. Arkwright. $1.00.

"Beautiful and Quaint Designs in Leaden Glass; entitled: A book of sundry draughtes principally serving for glasiers, and not impertinent for plasterers and gardiners." $2.40.

"Photography." A. Brothers. $6.00.

"Metal Work." A. G. Compton. Part I, $1.50.

"Cupola Furnace." E. Kirk. $3.50.

ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* THE MECHANIC ARTS MAGAZINE, *Scranton, Pa.*

1. Put this address both on the envelope and at the head of the letter.

2. Only questions of general interest to our readers will be answered.

3. No questions will be answered by mail.

4. Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.

5. The names and full addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.

6. Reference to inquiries previously answered should give date of issue and number of question.

7. Any book not out of print and for sale by regular dealers may be ordered through the Magazine.

ERRATUM.—May, 1899, Answers to Inquiries, No. 98, answer to (*b*) should read: If you substitute for the 33-tooth a 50-tooth gear, you will decrease this distance in the proportion of 50 to 33, and the distance that a point on the drum will travel during one revolution of the 100-tooth gear will be $\frac{.758 \times 33}{50} = \frac{1}{2}$ inch.

***

(116) What is the latest method of etching a copper plate from which to print visiting cards, cards for wedding invitations, and similar work? How are the letters placed upon the plate before being etched, how is the surface of the copper prepared, and what is the acid used for etching? Explain also the process of printing from such a plate.

A. M. P., Brooklyn, N. Y.

ANS.—The plate for plate printing (whether of steel or copper) is not etched, but engraved by hand, in which operation great skill is required. For a visiting card the name is first written on the polished surface of the copper with a pointed steel pencil; this writing is done freehand. Then, with an engraving tool, the letters are cut into the copper. The process of printing from engraved plates is fully described in HOME STUDY MAGAZINE, June, 1898, Answers to Inquiries, No. 240. The making of cuts for illustrating purposes is fully described in the present number, in answer to question No. 122. The acid used for etching these cuts is nitric acid. The ink used for printing from copperplates is lithographic ink.

***

(117) (*a*) What is the weight of a cubic foot of hard wood, and what of a cubic foot of steel? (*b*) Do I run any risk in employing two separate attorneys when applying for a United States patent?

V. D. T., Cornwall, Ont.

ANS.—(*a*) Hard woods vary considerably in weight; the average weight in pounds of a cubic foot of dry ash is 38; cherry, 42; ebony, 76; elm, 35; hickory, 53; lignum vitæ, 83; oak, 59; sycamore, 37; walnut, 38. Green timber usually weighs from one-fifth to one-half more than dry. The average weight of a cubic foot of steel is 490 pounds. (*b*) You cannot make two applications for the same patent at the same time. As far as getting advice is concerned, you may go to as many attorneys as you like; there is no risk whatever; patent attorneys may be trusted.

***

(118) (*a*) What is the best shape for a small greenhouse? (*b*) Is it necessary for a greenhouse to be glazed with double glass? (*c*) What is the best way to heat such a house—by hot air, hot water, or steam?

W. E. W., St. John, N. B.

ANS.—(*a*) The proper construction of small greenhouses can best be ascertained by writing to The Lord and Burnham Co., Irvington-on-the-Hudson, N. Y. Ask them to send you their catalogue entitled, "Greenhouses for Amateurs." (*b*) It is not necessary to have double glass, providing your heating plant is large enough to supply enough heat during the coldest weather. (*c*) Heat by hot water and use 4-inch cast-iron pipes.

***

(119) (*a*) What is the construction and principle of action of the "Which Way" pocket level advertised in THE MECHANIC ARTS MAGAZINE? (*b*) Give diagrams showing the principle of the steam separator and the steam loop. (*c*) Can a soldering iron be made of any piece of copper by simply tinning it, or does the copper have to go through some special process? (*d*) Is it a good plan, after putting fuel into a furnace, to shut the chimney damper; will it, to a certain extent, stop the cold air from rushing in?

J. D. S., California.

ANS.—(*a*) A description of the "Which Way" level appeared in the "Trade Notes" department of the April number. (*b*) The water held in mechanical suspension in wet steam being heavier, volume for volume, than the steam, it follows that, if the direction of flow of the wet steam be abruptly changed, the particles of water, by reason of their inertia, will continue in the original direction of the current, while the steam passes off in another direction. This principle is made use of in steam separators, like the one shown in Fig. 1. The steam enters at *c*, and is deflected by a curved partition, which gives it a spiral motion about the pipe *a*. The particles of water are thrown against the walls of the vessel, and run down to the bottom of the chamber, while the dry steam passes up through the pipe *a* and discharges at the outlet *d*. The separator is provided with a drip pipe *h* and gauge glass *g*. The four wings *b* destroy the spiral motion of the current of steam, and offer additional surfaces for the particles of water to adhere to. The steam loop is an appliance for automatically returning the water of condensation from a steam pipe or separator to the boiler. Its arrangement is shown in Fig. 2, where *a* is the boiler, *b* the steam pipe to the separator, and *k*

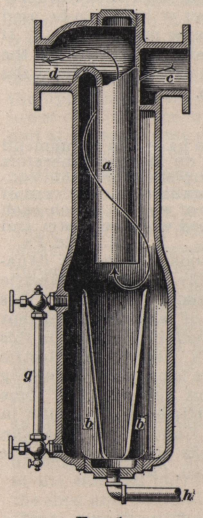

FIG. 1.

the steam pipe leading to the engine. The operation of the loop is as follows: Any water that has collected in the bottom of the separator *c* is forced up the riser *d* and through the horizontal pipe *e* into the drop leg *f*. Then, as soon as the sum of the steam pressure in the drop leg and the pressure due to the head *m* of water between *g g* and *h h* exceeds the boiler pressure, the check-valve *l* opens, and some of the water in the drop leg enters the boiler. The check-valve closes as soon as the boiler pressure

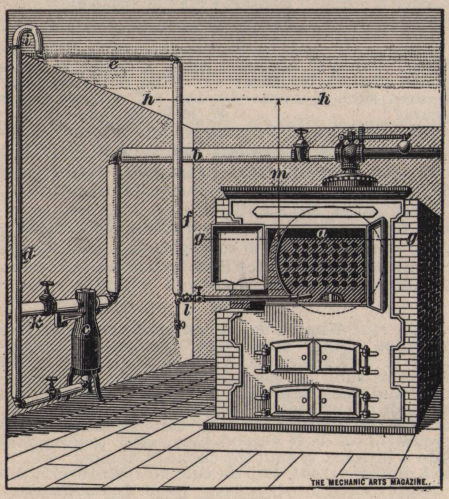

FIG. 2.

exceeds that in the drop leg; it opens again as soon as the pressure in the drop leg exceeds the boiler pressure. The loop at *i* prevents any water in the horizontal pipe *e* from flowing back into the separator. (*c*) Any piece of copper or brass can be used for a soldering iron, copper being preferable. (*d*) If you do not want a freshly coaled fire to burn up, the damper may be closed. This certainly prevents the entrance of air to the furnace.

***

(120) I would be pleased to have you recommend a clear and concise treatise on electric generators and motors, a book giving complete information concerning the construction, peculiarities, and care of same, together with the class of work to which each is adapted. I also want a good work on steam and water piping for large plants. F. P. K., Erie, Pa.

ANS.—The most suitable book treating on dynamos and motors is probably "Dynamo-Electric Machinery," by S. P. Thompson, price $4.75. This does not treat very fully of alternating-current work, but you could obtain such information in this line from the same author's "Polyphase Electric Currents," price $3.50. There is no work on piping that we can recommend, but you will find some interesting and instructive articles on the subject in recent numbers of "Power" and "The American Machinist." The above books are for sale by The Technical Supply Co., Scranton, Pa.

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(121) (*a*) I have a Laidlaw-Dunn-Gordon duplex boiler feed-pump, each piston of which makes about 15 strokes per minute. One piston travels too far at one end, pushing the joint of the steam ring over the counterbore of the cylinder; this allows steam to blow through the joint and out at the exhaust, and thus causes the piston to stick at this end. It hangs worse when running slow or when steam is rising than at other times. I have tried shortening valve stem so as to make it take steam earlier, but this has no effect; but by setting up the gland at the stuffing-box, and thus increasing the friction at that side, the stroke is shortened and the trouble ceases, but, of course, it begins again in a short time. Please give remedy. (*b*) Will a bad wabble in a flywheel (not a bandwheel) 11 feet in diameter, and making 105 revolutions a minute, cause the engine to pound?

F. M. E., Gainsville, Texas.

ANS.—(*a*) The cause of the trouble appears to be that there is too little compression, due probably to leakage of steam from the compression space after the piston covers the exhaust passage. The leak may be between the valve and its seat, or around the piston ring—probably the latter. The remedy is to provide sufficient compression by stopping the leak. In some pumps the compression is controlled by valves, which regulate the amount of opening of a connection between the steam and exhaust passages; if your pump is provided with this attachment, the compression can be increased by closing the valve so as to reduce the quantity of steam that escapes from the compression space. (*b*) An unbalanced flywheel is very likely to cause the engine to pound; in any case, it will cause extra stresses in the shaft and wear on the bearings.

***

(122) (*a*) Please explain fully the process by which cuts similar to those used in THE MECHANIC ARTS MAGAZINE are made. (*b*) How are calling cards printed from a copperplate engraving, the letters being sunk in the plate? I do not understand how the ink is applied. (*c*) What kind of steel is used in the manufacture of steel magnets, and how is the steel hardened? G. C. B., La Crosse, Wis.

ANS.—(*a*) The first step is to make the drawing from the sketch supplied to the illustrator. The drawing is generally made about twice as large as the cut is intended to be when printed. This is done to get sharper lines. On the drawing, as handed to the engraver, is marked the reduction that is to be made. If the cut is required to be half the size of the drawing, the latter is marked "reduce ½." Other reductions are generally given in figures, thus, "reduce to 3¼ inches." A reduction of course affects both the length and the width. Thus, if a drawing 9 in. × 6 in. were marked "reduce ⅓," the cut would be 4½ in. × 3 in. The engraver takes a photograph of the drawing, reduced to the required size. A print is then taken from the negative on a sensitized zinc plate. The next process is to etch this plate with acid. Where the dark lines occur on the plate (corresponding to the lines on the drawing), the acid cannot attack the plate. The result is that the plate is eaten away wherever a white space shows on the drawing, and is left unmarked wherever ink lines occur. Next, the plate, or "cut," is routed where large spaces occur, being cut down about $\frac{1}{10}$ of an inch below where the acid has eaten. This insures that if, in printing, the paper bulges somewhat inside these spaces, it will clear the plate. Close up to the lines, the plate is allowed to remain just as the acid left it—that is, there is no routing done nearer than within about $\frac{1}{50}$ of an inch of the lines. It is now, together with a proof taken from it, given to the engraver to "trim up," he being also provided with the original drawing as a guide. He removes any imperfections that may now appear in the plate, the proof before him serving to guide him in finding these bad spots. The cut is then "blocked," that is, tacked down on a smooth, level piece of hard wood, of such a thickness that the height from the under side of the wood to the top surface of the plate is just equal to the depth of type used in the accompanying text. In technical language, the plate is made "type high." (*b*) A strong ink is used for this purpose,

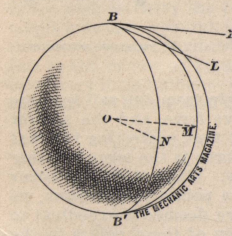
applied to the plate by means of a *ball*, as it is called by printers. This is a spherical instrument, made of sheepskin and stuffed with wool or hair. This is coated with ink and the latter thus rubbed well into the lines of the plate. A card is then laid on the plate and the two passed between rollers, under a heavy pressure. The ball is used to ink the plate again after every imprint. (*c*) Various fancy steels, such as tungsten, etc., are often spoken of in this connection, but in the majority of cases a cheap, low-grade steel, costing from 2½ to 4½ cents a pound, wholesale, is employed, and is quite suitable. It is hardened by heating to a bright cherry red and cooling right out in cold water. It is magnetized by stroking it across the poles of a powerful electro-magnet.

***

(123) I want a simple rule or rules for finding the area of any part of the surface of a sphere, so as to get the size of blank required to make it.

W. L. B., Meriden, Conn.

ANS.—Every plane section of a sphere is a circle; a section made by a plane passing through the center of the sphere is called a *great circle*. A *spherical lune* is a portion of the surface of a sphere bounded by two semicircumferences of great circles. A *spherical polygon* is a portion of the surface bounded by three or more arcs of great circles; a spherical polygon bounded by three sides is called a *spherical triangle*. The *angles* of a spherical figure are the angles between the arcs of great circles which bound the figure. A spherical angle is measured by the angle between the planes of the great circles containing the angle, or by the angle between two tangents, one drawn to each of the circles at their point of intersection; thus, the spherical angle MBN is measured by either of the equal angles KBL or MON. The angle $MB'N$ is also measured by MON, and therefore the angles MBN and $MB'N$ of the lune $MBNB'$ are equal.



Let R = radius of the sphere;
A = area of the surface of sphere;
π = ratio of a circumference to its diameter;
L = area of a lune whose angle contains B degrees;
T = area of a triangle the sum of whose angles contains S degrees;
P = area of a polygon of n sides the sum of whose angles contains S degrees.

The following formulas are proved in books on geometry:

$$\pi = 3.1416 \text{ (approximately)} \quad (1)$$

$$A = 4\pi R^2 \quad (2)$$

$$L = \frac{\pi R^2 B}{90} \quad (3)$$

$$T = \pi R^2 \frac{(S - 180)}{180} \quad (4)$$

$$P = \frac{\pi R^2 [S - (n-2)\,180]}{180} \quad (5)$$

The area of any portion of the surface of a sphere bounded by arcs of great circles can be found by these formulas.

***

(124) (*a*) Is there any difference between a freight-car triple valve and a passenger-car triple valve? (*b*) Are they all "standard"? If so, why are some marked F and others P? (*c*) What is the origin of the expression "a stuck wedge"? Seeing that the wedge remains stationary and that it is the driving box that moves, would it not be more correct to say "a stuck box"? (*d*) Explain how, on an 8-wheeler, a stuck box is detected, and give the remedy therefor. (*e*) Why is it that, in running the 8-wheeler and putting the reverse lever three notches back of center, it continues to run forward, and yet is as square as if notched up four notches and in back motion? (*f*) Standing still, if the engine is hooked up two notches and given steam, it won't move. Why is this? (*g*) What is the coal capacity of a pit 8 feet 5 inches long, 4 feet 8 inches wide, 3 feet 1 inch deep? Show the working of this problem.

R. F., New Orleans, La.

ANS.—(*a* and *b*) Yes; the size of the ports is not the same in each case. As the triples have the same outward appearance, it is necessary to distinguish between them in some way; hence the use of P to denote passenger and F to denote freight. (*c*) The point you raise is an amusing one; you are certainly at liberty to talk of "a stuck box" if you prefer it, as, also, you are to talk of a hot journal instead of a hot box, or a hot crosshead gib instead of a hot guide. When the contingency in question does occur, the part we have to *move* is the wedge, in order to free the box. It seems rational, then, to talk of a "stuck wedge." You say that the *box* moves; we prefer to regard the frames (and, therefore, the shoes and wedge) as moving. True, when a high or a low spot in the track is struck, the wheel (and box) moves momentarily in space; or, in other words, relatively to the normal rail level and therefore to the frames of the engine; but when running along an ordinary level track the box is at rest relative to the rail, while the frames, due to the engine rocking on her springs, move up and down. So that, speaking generally, we may say the wedge moves up and down on the side of the box. Of course, the point is not of the least importance—nothing but a verbal quibble. (*d*) The sticking of a wedge is readily discovered by the "riding" of the engine, the spring of that particular wheel being then inoperative. Even if not actually stuck fast in the jaw, there being still a little vertical motion, the engineer can tell by the loss of freedom in the engine's riding that something is not quite right. The engineer is sometimes warned of a stuck wedge by finding a hot journal, which is usually the cause of the trouble. To remedy it, slack the upper nut of the wedge bolt and tighten up the lower one (the one underneath the frame clamp) and at the same time get some one to jar the pedestal by hammering. You can get a bar on to it from the outside, a third party hammering on the bar with a large hammer or anything available. It is better, however, to use a small hammer directly on the frame itself, as by this method a better effect can be produced. If the wedge won't move, put a crowbar underneath the frame and "lever" on the top of the wedge, the pedestal legs being jarred as before. At the outset, put some turpentine or naphtha down between the stuck surfaces. Either is very searching stuff; if neither is at hand, use kerosene from the air-pump supply. If the engine has two shoes and a wedge, it will be more difficult to get at the latter from the top, as the shoe will be in the way, reaching, as it does, to the top of the pedestal jaw, and the wedge being pretty thin at the top. You can work directly on its top, however, with a bar bent a little at the end and narrow enough to go down between the shoe and pedestal. If you find you can't move things, give the surfaces a good dosing with kerosene, as just mentioned, and then run the wheel up over a piece of iron or hard wood from 1 inch to 2 inches thick; the sudden drop of the frames as the engine passes over this will in most cases separate the parts. (*e*) If the engine has been out of the shops for a very long time, there will be a lot of play everywhere—

reach-rod, link-hanger, and saddle pins, to say nothing of the reverse-lever catch and sector teeth (when not tapered), albeit small in amount. All this throws the engine more into full gear, so that when in the third notch from the center in the back gear, she is nearer mid gear than appears to be the case. If, in addition, she has been set about an eighth blind in full gear, the mid-gear port opening will be so small that although the steam is working adversely to the engine (albeit reduced in degree, as shown above), the amount may be such as not to appear to check the engine's speed much. But the fact is still there that the engine *is* taking steam against herself and will eventually check up. (*f*) From what we infer as to the pitch of notches, when you pull her up two notches, that is, into the third notch from the corner, she will be cutting off at about 15 inches, if a 24-inch stroke. In this position, if the main rod is 7 feet long, one of the cranks will be about $10\frac{1}{2}°$ past the quarter. So if she has stopped in this position, the above-mentioned crank will get no steam when the throttle is opened, and the other crank being only $10\frac{1}{2}°$ off dead center, is in an unfavorable position to make much use of its steam, the main rod being too much in line with piston rod. If one crank is on the quarter, it will be in a pretty favorable position for turning the wheel, but the port opening is nearly closed. The other crank, being on the center, does not count at all. Then, again, one of the cranks may have stopped such an amount past the dead center as to be at right angles to its main rod, and therefore in a most favorable position for turning; in our case, the angle will be $81\frac{3}{4}°$ or $8\frac{1}{4}°$ from the quarter; here there will be more port opening, but the other crank will be doing nothing—in fact, compression would be against her, if running. It all depends, in short, on the position the engine has stopped in. There will only be about three-fifths of the port open, anyway, notched up as she is; this, however, would suffice if the crank had stopped in a suitable position and there were very little weight behind the tender. If the engine were much worn, that would be in favor of her starting in the third notch, as the link would be nearer full gear than the lever indicated. (*g*) First, to find the capacity of the pit in cubic feet, multiply the three dimensions together. Thus, $8\frac{5}{12} \times 4\frac{3}{8} \times 3\frac{1}{12} = 121.1$, say 121, cubic feet. Now, to find the weight of coal the pit will contain, it is very evident one must know the size of the coal, as you can get more weight of lump coal in than you can of buckwheat, owing to its lying more "solid"—not so much air space. (And there are many intermediate sizes.) Then, again, the coal may be either anthracite or bituminous; the former is from 10 to 15 per cent. heavier than the latter. To find how many tons (of 2,240 pounds) there can be stowed in the above bin, bunker, pit, or whatever it is, divide 121 by one of the following numbers, according to the kind and size of coal:

Anthracite—Buckwheat, 44; egg, 43; lump, 39.

Bituminous—Small, 50; large, 45.

For example, if you are using lump anthracite, the pit will hold $\frac{121}{39} = 3\frac{1}{10}$ tons, about. If small bituminous, $\frac{121}{50} = 2\frac{2}{5}$ tons, about. Judging from the locality whence you write, you evidently use only bituminous coal; the information, however, regarding anthracite, may be found of interest.

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(125) Referring to your answer to question No. 89 in the April issue of THE MECHANIC ARTS MAGAZINE, I wish to say that a locomotive (assumed to be in a position to move forward) can start the greatest load when the crank is at the lowest position. There are two excellent reasons for this: *first*, the side of the piston head subjected to steam pressure is not reduced in effective area by the presence of a piston rod in the active end of the cylinder; *second*, the useful force tending to produce tractive effort at the rail is the horizontal component of the push or pull in the connecting-rod; the vertical component has the same character and value in both positions of the crank, and produces no other effect than to lessen the weight on the main driver axles by transferring some of the weight of the boiler and frame from the axle on to the crankpin. Now, it is easy to show that the greatest pressure between the axle journal and brass is induced when the crank is at its highest position, and therefore there is then the greatest frictional resistance to be overcome by the connecting-rod, and therefore so much less tractive force; similarly, there is the least frictional resistance when the crank is at its lowest position, and consequently there is then the greatest net tractive force. I have spoken to a number of locomotive engineers about this matter, and they all agree with me.

T. H. R., North Adams, Mass.

ANS.—While we acknowledge to some extent the justness of your criticism, it appears to us that the answer given fits the question asked exactly. Evidently the questioner had an idea that the difference

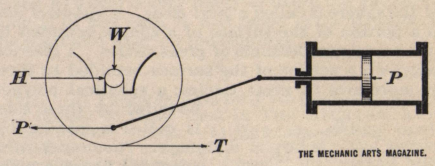

FIG. 1.

in the height of the crankpin from the rail in some way influences the tractive force, and the answer shows the well-known fact that, neglecting internal friction, etc., the tractive force is the same whether the crank is above or below. While it did not occur to us to take account of the points you mention, we should not in any case have deemed it expedient to include a refined discussion of these points in the answer. As to your contentions, we think you have altogether overestimated the importance of the two points you mention. We, of course, grant that the decreased area due to the piston rod lessens the pull when the crankpin is above the axle (although this criticism fails in the case of engines having a tailrod, i. e., extension of piston rod through front head). Let us, however, go a little more deeply into the question of friction. In Fig. 1, with the crankpin in its lowest position, it is evident that

$$P = T + H,$$

or,

$$H = P - T,$$

where H is the horizonal pressure between journal and frame; T is the tractive force; and P is the horizontal component of the connecting-rod thrust, and is equal, of course, to the total pressure on the piston. When the pin is above the center, we have the condition shown in Fig. 2. Here, $H = P + T$. In both cases, taking moments about the center of the journal,

$$T = \frac{r}{R} P.$$

Hence,

$$H = P\left(1 - \frac{r}{R}\right) \text{when pin is below.}$$

$$H = P\left(1 + \frac{r}{R}\right) \text{when pin is above.}$$

For a fair value of $\frac{r}{R}$, we may take .4; then, for pin below, $H = .6\ P$, and for pin above, $H = 1.4\ P$. We must, however, take into account the crank on the other side. In either case the opposite crank is on a center, and $H = P$. Now, let W = the total load on

one journal-box. Combining the vertical force W with the horizontal forces P, .6 P, and 1.4 P, we have as the three resultants:

$$F_1 = \sqrt{W^2 + P^2},$$
$$F_2 = \sqrt{W^2 + (.6\,P)^2},$$
$$F_3 = \sqrt{W^2 + (1.4\,P)^2}.$$

Suppose the cranks are as shown in Fig. 3; then the force on one journal is F_1, and that on the other is F_2.

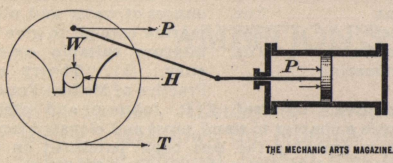

FIG. 2.

When the cranks are as shown in Fig. 4, the force on the one journal is F_1, and that on the other is F_3. The force W is always considerable, compared with the force P, so that, in practice, F_1, F_2, and F_3 are not very different. Besides the inequality of the forces on the two sides of the locomotive, the fact that frequently these forces are acting in opposite directions, as in Figs. 1 and 2, throws great doubt on the influence of this excess of F_3 over F_2 on the tractive force. If we wish to carry the refinement still further, we might take into account the rotating parts, etc. On the whole, we are inclined to think that the friction due to the excess of pressure on the journals will exert very little influence on the load that the engine can start. With a piston rod extending through the

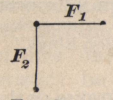

FIG. 3.

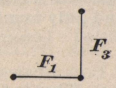

FIG. 4.

front end, we would as soon take chances with the crankpin above. We may add that, so far as our personal experience among runners goes, we have always found the opinion general that a better start can be made from the top than from the bottom quarter.

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(126) What is the greatest height above the surface of the water supply over which a siphon will draw water? H. M. B., San Francisco, Cal.

ANS.—At sea level, the greatest theoretical height is 34 feet—the height of a column of water that will be supported by the pressure of the atmosphere. At greater elevations, the atmospheric pressure, and, consequently, the theoretical height to which water can be raised, is less. Practically, it is generally difficult to operate a siphon over an elevation of more than from 20 to 24 feet, depending on the elevation above sea level and the size and length of the pipe.

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(127) (*a*) When a student of The International Correspondence Schools, Scranton, Pa., has completed the Complete Course of Architecture, he is presented with a diploma or certificate of proficiency. Is this as good as a license from a board of examiners of architects? (*b*) Is there a law in the state of Pennsylvania prohibiting an architect from practicing his profession unless he has a license or certificate from some technical institute? I. S., Osnaburg, Ohio.

ANS.—(*a*) The certificate or diploma from The International Correspondence Schools means that the student has passed with credit through a prescribed course of study. It represents work done, and is as much a credit to the holder as a certificate from a board of examiners. (*b*) There is no law in Pennsylvania requiring a practicing architect to have a license or diploma. Illinois is the only state having such a law.

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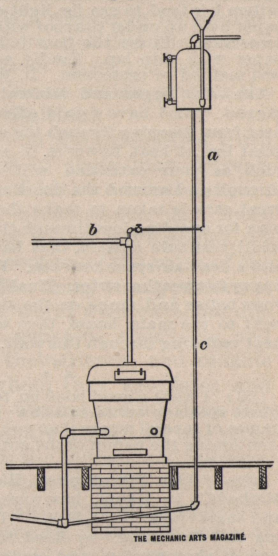
(128) (*a*) On a low-pressure hot-water heating system, to which pipe should the expansion pipe be connected, and why? (*b*) Referring to the enclosed sketch, *a* is a relief pipe taken from an overhead system of heating; are the connections shown correct? (*c*) In the same sketch, *b* is a pipe that feeds three radiators below it and one on the floor above. In connection with these radiators, is the method shown of running the pipes to the expansion tank the best? (*d*) If, instead of pipe *c*, as shown, connecting the expansion tank to the return pipe, the connection to the latter were made from below, by means of an elbow so as to form a sort of trap, would better results be obtained in any way, and would there be less tendency for the water to boil up in the expansion tank? (*e*) When making screwed joints in hot-water or steam pipes, I have always used a mixture of red lead, linseed oil, and salt; it has given fairly good results, but if you know of anything better, I shall be glad to have it. F. W. R., New London, Ohio.

ANS.—(*a*) The expansion tank should be connected to the top of the flow main as you show it. This will allow steam to escape into the tank, and thence to the atmosphere, if the boiler should generate steam. (*b*) The connections shown are correct, provided that the steam or air cannot blow out of the mouth of the funnel shown on the top of the relief pipe. A stop-cock should be placed on this pipe between the T which enters the side of the expansion tank and the funnel. It is not necessary to place a vent-cock at the point where the relief pipe connects to the flow main; in fact, this cock should be taken out. It is best to have an open communication between the flow main and the expansion tank. (*c*) The method of running the expansion pipes as shown in the figure will not affect the heating of the radiators you mention. The arrangement is as good as any other arrangement. (*d*) No. A trap on the pipe *c* will not benefit the arrangement. If the pipe *a* is quite large, say 1 inch or 1¼ inches in diameter, it will prevent hot water from backing up in the expansion tank, by allowing steam to escape into the expansion tank, so that the boiler will remain charged with water, even when boiling furiously. (*e*) A mixture of good red lead and boiled linseed oil is about as good a cement as can be used on hot-water piping.



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(129) Will you kindly give a rule for adjusting the long-bubble tube beneath an engineer's transit, so that, when level, it will be parallel with the line of sight? The transit is to be used for leveling purposes. J. H. L., Lyonsville, Cal.

ANS.—Choosing a reasonably level piece of ground, drive two pegs A and B several hundred feet apart, and set up the instrument midway between them.

With the level on the telescope truly horizontal, read the rod held upon each peg. The difference of the readings will be the true difference of the elevations of the pegs, no matter how much the instrument may be out of adjustment. Then set the instrument over the peg A, and measure the height of the cross-wires above this peg. With the target set at this height, plus or minus the difference in the elevations of the pegs, according as the peg A is above or below the peg B, hold the rod on the peg B and direct the telescope so as to bring the cross-wires exactly upon the color lines of the target. In this position adjust the level tube so as to read truly horizontal. The operation is somewhat simplified by driving the pegs to exactly the same elevation. Also, instead of setting the instrument over one peg, it is generally more convenient to set it as near as it is practicable to read the rod held upon it, and use this reading of the rod for the height of the cross-wires above the peg. In order to insure accuracy, the entire operation should be repeated.

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(130) I am about to build an extension to my house, consisting of a kitchen 12 ft. × 14 ft., facing north, and I would like it as near frost-proof as possible, since the range and tank will be connected to the city water. I have thought of putting an inch or so of mineral wool at center of studding (which is 2 in. × 4 in. before plastering), leaving an air space on each side of the wool. The space above the rafters I intend to use for light storage. Would tar paper held up under the roof with strips be sufficient protection? Under the floor I thought of using tar paper with ship lap. Kindly advise me as to the best method of protection. D. M. L., Omaha, Neb.

ANS.—Tar paper and mineral wool, used as you suggest, would have a good effect in preventing the heat from escaping through the walls and roof. The great loss of heat, however, in an exposed position, such as your extension will occupy, will occur through and around the doors and windows, unless great care is taken to make them tight. The best plan for avoiding loss through the door is to build a small vestibule outside, thus having a double door and a dead-air space between. For the windows use heavy felt weather strips. Finally, be sure to arrange your boiler and range on the side of the extension next to the main house, thus taking advantage of heat radiating through this wall.

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(131) I want a good book on topography, one that treats specially on calculation; kindly give me the names of several works that you would recommend, mentioning the names of the authors, and the prices. O. B., Mexico.

ANS.—"The Topographer, His Instruments and Methods," by Haupt, has numerous maps, plates, and engravings; price, $3.00. "Topographical Drawing and Sketching," by Reed, includes the application of photography, and contains 24 large plates; price, $5.00. These books can be obtained of The Technical Supply Co., Scranton, Pa.

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(132) In the appendix to Hopkins' "Experimental Science," there is an illustration and explanation of an Edison phonograph motor. Kindly give the dimensions of this motor and the size of wire to be used; also, explain how to wind the armature for two brushes. Can this motor be made to run on 4 watts? E. A. A., Granite Falls, Minn.

ANS.—We refer you to the publishers of the book named, Munn & Co., New York, N. Y.

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(133) (*a*) Kindly give a recipe for blue ink for branding on wood. (*b*) Give the names, prices, etc. of any books that you can recommend on the designing of steel structures. I particularly want information on how to design and build a steel structure to carry a water tank, 20 feet in diameter and 20 feet deep, to be 60 feet above ground. If you can also tell me where I can obtain plans and specifications for this, and what the same are likely to cost me, I shall be much obliged. York, Ontario.

ANS.—(*a*) Boil borax and shellac in water till they are dissolved, and withdraw from the fire. When the solution has become cold, add rest of 25 ounces of water and ultramarine enough to give the mixture suitable consistency. (*b*) "Theory and Practice of Modern Framed Structures," by Prof. J. B. Johnson and others, devotes a chapter to stand pipes and elevated tanks. This is probably the best book published on the designing of steel structures; price, $10.00. Considerable information can doubtless be obtained, also, from a book entitled "Stand-Pipe Accidents and Failures," by Prof. Wm. Pence; price, $1.00. Both books are for sale by The Technical Supply Co., Scranton, Pa. We know of no published specifications for elevated tanks; but general plans and considerable other information can doubtless be obtained by addressing any of the construction companies making a specialty of this work. The Chicago Bridge and Iron Company, Washington Heights, Chicago, Ill., have given considerable attention to this class of construction.

Shellac	2 oz.
Borax	2 oz.
Water	25 oz.
Gum arabic	2 oz.
Ultramarine	—

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(134) Kindly explain how piston packing rings are made. S. H. D., Franconia, N. H.

ANS.—You will find the information you require in HOME STUDY FOR MACHINISTS, STEAM ENGINEERS, ETC., August and July numbers, 1897, in an article in two parts, entitled "Locomotive Piston Rings."

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(135) (*a*) What is the best treatise on the manufacture of brick? (*b*) I also want a good book on the construction of roads; can you tell me of one? L. L. G., Greenville, Miss.

ANS.—(*a*) "A Rudimentary Treatise on the Manufacture of Bricks and Tiles," by E. Dobson, is said to be a good work on this subject; price, $1.00. (*b*) "Highway Construction," by Austin T. Byrne; price, $5.00. Both books are for sale by The Technical Supply Co., Scranton, Pa.

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(136) (*a*) In what book or periodical can I obtain information as to the number of British thermal units (B. T. U.) of heat developed during the chemical union of various elements, together with a full description of the method of determination? For instance, the chemical combination of two of hydrogen with one of oxygen to form water; of one of carbon with two of oxygen to form carbon dioxide; of one of carbon with four of hydrogen to form marsh gas; and so on. (*b*) What is the method of determining the number of B. T. U. contained in any given quantity of fuel, such as a pound of coal, a gallon of oil, a cubic foot of coal gas, etc.? (*c*) Where can I obtain information regarding the Parsons and De Laval steam turbine? D. C. W., Johnstown, Pa.

ANS.—(*a* and *b*) "Physico-Chemical Methods," by Dr. J. Traube, translated by W. L. Hardin, $1.50; "The Calorific Power of Fuels," by Herman Poole. These books can be obtained of The Technical Supply Co., Scranton, Pa. (*c*) Articles have appeared from time to time in technical journals, particularly in "London Engineering." Probably the information can be obtained most directly from the manufacturers. Address C. A. Parsons & Co., Newcastle-on-Tyne, Eng. The De Laval steam turbine is manufactured in Stockholm, Sweden; the exact address of the company we do not know.

SELF HELP

AMBITION'S RIGHTFUL CALL.

LECKY, in his "History of European Morals," lays down the principle that "the most effectual method that has been devised for diverting men from vice is to give free scope to a higher ambition." This statement we find supplemented and emphasized by Henry Ward Beecher in his lectures to young men, to whom he says: "We must endeavor to inspire every calling in life with an honest ambition for intelligence."

The modern system of technical education, besides being of incalculable value to the workingman, renders inestimable aid to men not only in the engineering, but also in the ranks of the liberal professions as well: to the lawyer, the physician, the clergyman, the editor, and the litterateur. The successful man has one distinctive and noble characteristic: he is, in season and out of season, industrious. No man that expects success can afford to become an idler after he obtains his education. That time should mark the real beginning of a life of arduous study. The more a man advances in professional work, the more he finds he needs to know. In the very outset of the race of life, he will be distanced if he does not devote himself to earnest and systematic study. How many young men begin careers with highest promise, as journalists, jurists, physicians, civil engineers, surveyors, and the like, and yet, after a few years, drop into comparative oblivion. Examine their lives closely, and you will find that, at a certain period, they thought themselves independent of study's aid, and at once began to fall behind in the race. Instead of their taking heart and resuming courage, they lost resolution and fell by the wayside.

We must either advance or recede. There is no such thing as standstill in the road of success. If young men, just across the threshold of their professional careers, employed spare moments in self-improvement, failure would be in their lives an unknown quantity. The value of any possession is to be chiefly estimated by the relief that it can bring us in the time of our greatest need. In this respect, no possession can equal the habit of study, which, apart from the knowledge it assures us, secures discipline of mind and passion, evenness of temper and confidence in self—of truly inestimable value in the dark days that beset every human life. This habit must, to be either vigorous or useful, like virtue itself, of which it is an emanation and a manifestation, show itself regularly and constantly active, not breaking forth occasionally with a transient luster, like the blaze of a comet, but regular in its returns, like the light of day; not like the scented gale which sometimes feasts the sense, but like the ordinary breeze which purifies the air and renders it healthful.

When we reflect on the established truth that the happiness of every man depends more on the state of his own mind than on any one external circumstance, nay, more than on all external things put together, we may have just conception of the value of the habit of study. How many young persons at first set out in the world with excellent dispositions of heart, generous, charitable, and humane; kind to their friends, and amiable among all with whom they associate; and yet, how often do we not see all these fair appearances unhappily blasted in the progress of life, through the influence of idleness, which leaves an open door in the youthful heart to loose and corrupting pleasure; and these very persons, once a promise of blessing to the world, sink down, still in early life, to be the burden and nuisance of society. Happy is that young man who spends his time in making himself wise; who, as the will and understanding are the two ennobling faculties of the soul, thinks himself not complete till his understanding is equipped with the valuable furniture of knowledge, and his will strengthened by studious industry; who, when ambitious, is not to be admired for a false glare of science, but lives for the gentle and sober luster of unfailing wisdom and exact knowledge.

THE STORY OF PROF. BARNARD.

THE story of the career of Prof. Edward Emerson Barnard, the astronomer, is that of a poor boy, who acquired an interest in such work by reading a book which happened into his hands, and which resulted in the keen search for more information. Today he stands in the front rank of his profession.

Professor Barnard was born in Nashville, Tenn., on December 16, 1857, and his education was limited to two months' attendance at the common school besides such instruction as his mother could give him. Fatherless and destitute at the close of the war, he went to work in a photographic studio, continuing at that occupation until 1883. During that time he had mastered every department of the photographic art. Throughout his career his was a single-minded struggle for existence, as he was handicapped by poverty from the first, and compelled to fight the battle of life alone.

Early in life he became interested in optical matters, which interest was increased by the use of the lenses in the gallery where he worked. In 1876 he came into possession of a copy of Dr. Thomas' book on "Practical Astronomy," and it awakened a thirst for astronomical knowledge, which has never since ceased to be his controlling motive. This work, long since left behind in the great advance of science, was like a revelation. It told stories of the stars and the planets, and the wonder revealed by the telescope. Now, for the first time, he had some idea of the uses of astronomical instruments. He had never seen either a telescope or an observatory. All he knew of the literature of the subject was found in this old book. From the maps of the constellations and other engravings, he speedily learned to identify the objects in the sky about which he had been reading, and the descriptions of celestial wonders had now a new interest. Then came the desire to possess some kind of a telescope, and finally he obtained the object lens of a common spy glass, and mounted it in a paper tube made by himself.

In August of that year he met, in Nashville, Professor Simon Newcomb, the distinguished Washington astronomer, and received from him advice and kindly suggestion in regard to the future; and this encouragement was of much value in his efforts to accomplish something with the new instrument. In 1883 he left the photographic business, having received a fellowship in astronomy at the Vanderbilt University. He was promptly placed in charge of the observatory attached to that institution, and continued his researches with the 6-inch equatorial telescope. This instrument was superior in power to that previously used, and having a fixed equatorial mounting, with driving clock and micrometer, was much better adapted to the work of determining the absolute positions of unknown objects.

In 1888 he was offered a position in the Lick Observatory, then about to be opened with the largest equatorial and the best equipment of astronomical instruments in the world. The temptation of superior facilities for astronomical work and discovery, and the opportunity to devote his whole time and strength under these circumstances to the work of his life, left no hesitation in regard to his future course, and, much to the regret of the University and the citizens of Nashville generally, he left for Mt. Hamilton. There he began with increased enthusiasm a series of brilliant observations and discoveries, which are familiar to the astronomical world, and to the readers of scientific literature.

His long experience in all departments of photographic art was turned to practical account at the Lick Observatory in the direction of celestial photography. He was the first to photograph the Milky Way, and show the wonderful forms of its structure. The work attracted widespread attention, and down to the present time has not been equaled by any one.

Among his great achievements were the discovery of the fifth moon of Jupiter, and the finding of a new comet, by means of photography. The services of Professor Barnard in the line of astronomical research have been recognized by scientific societies. He has been a Fellow of the Royal Astronomical Society of London since 1887, and is also a member of the British Astronomical Association, the American Academy of Arts and Sciences, the American Association for the Advancement of Science, and many other bodies. His work has lately been recognized by the French Academy of Sciences by the award of the Lalande gold medal. In 1893 the degree of Doctor of Science was conferred on him with the Arago gold medal, valued at 1,000 francs, for the discovery of the fifth satellite of Jupiter. In 1897 he received the gold medal of the Royal Astronomical Society of Great Britain, and in 1898 was elected Foreign Associate of the Royal Astronomical Society.

EDUCATION EQUALIZES FORTUNES.

EDUCATION levels all undue distinctions and removes all disparities of fortune. Many of the crucial social problems of today would be quietly and forever solved—solved to the satisfaction of all, and this republic thus made to endure forever, for the perpetuation of civilization in its most ennobling form—if education, practical education, were acquired by all.

"Give away all you can," is the advice of John D. Rockefeller, who has bestowed millions upon the educational improvement of his fellow citizens. Give it away, say we, in education. Help your struggling fellow citizen to acquire knowledge. He will repay you, and the community at large bless and honor you.

"I had a hard struggle to get a foothold," said Mr. Rockefeller, as quoted by "Success." "As a boy just out of school, I found myself looking for a situation early in life. I walked all over town in an attempt to find something to do. I visited every railroad office, every store, and, in fact, every place in the city where I thought I could find employment. Everywhere I met with discouragement, until I found one man, God bless him, who took me into his office and gave me work, and that man was H. B. Tuttle.

"That was the beginning, and a few years later I started a little business of my own, with a partner. In a short time came a crisis in our affairs, and it was necessary for our young firm, which was beginning to branch out, to raise more money. I remembered my friends and acquaintances, and called on them, one after another. Many expressed the most profound interest in our firm, but that's all."

Mr. Rockefeller then declared that at this critical moment he bethought himself to try the bankers, and finally visited the office of a dear friend, Mr. T. P. Handy. Mr. Handy, after hearing Mr. Rockefeller's statement, placed at his disposal the sum of $2,000. Mr. Rockefeller left the bank full of hope, standing up straight and erect, and considered himself one of the business men of Cleveland.

Reading from a small yellow-covered book which was his ledger in boyhood, Mr. Rockefeller found the following item: "Income from December 26, 1855, to January 26, 1856, $50; and I lived within my income! Out of that I paid my wash-woman, my board, and saved a little and put it away. I see that I paid in the Sunday School one cent, which was all I could afford. I was as independent in those days as Mr. Astor. I remember the clothes I bought; not fashionable, but cheap and good." For the year beginning November, 1855, to November 1856, Mr. Rockefeller's clothing cost him just $9.00. This man, whose clothes cost nine dollars a year, has given $7,000,000 to the University of Chicago, and his other charities are so munificent that he employs a man on a large salary to look after them.

The richest man in the world is, Mr. Rockefeller might have added, he who has useful knowledge sufficient to make his life purposeful, honest, and happy.

THE CONQUEST OF KNOWLEDGE.

THE maxim that "Labor conquers all things," holds especially true in the case of the conquest of knowledge. The road to learning is alike free to all who will give the labor and the study requisite to gather it; nor are there any difficulties so great that the student of resolute purpose may not surmount and overcome them. It was one of the characteristic expressions of Chatterton, that God had sent his creatures into the world with arms long enough to reach anything if they chose to be at the trouble. In study as in business, energy is the great thing. We must not only strike the iron while it is hot, but strike it until it is made hot. It is astonishing how much may be accomplished in self-culture by the energetic and the preserving, who are careful to avail themselves of opportunities, and use up the fragments of spare time, which the idle permit to run to waste. Thus Ferguson learned astronomy from the heavens while wrapped in a sheepskin on the highland hills. Stone learned mathematics while working as a journeyman gardener; Drew studied the highest philosophy in the intervals of cobbling shoes; and Miller taught himself geology while working as a day laborer in a quarry.

CHARACTER BUILDING.

CHARACTER building is the great work of the teacher. If men are not trained to be honest, persevering, energetic, and progressive, to be well-balanced in their character, all their knowledge is in vain. This country is looking for strong men, for leaders, for steadfast men, for men of character, fitted by technical education for leadership in the trades and professions.

MODERN MECHANICAL PROGRESS.

IN THE useful and practical arts, many inventions and contrivances, to the production of which the degree of ancient knowledge would appear to us to have been adequate, and which seem quite obvious, are yet of late origin. The application of water, for example, to turn a mill, is a thing not known to have been accomplished at all in Greece, and it is not supposed to have been attempted at Rome till in or near the age of Augustus. The production of the same effect by wind is a still later invention. It dates only from the seventh century of our era. The propulsion of the saw by any other power than that of the arm was treated as a novelty in England so late as the middle of the sixteenth century. The Bishop of Ely, ambassador from the Queen of England to the Pope, says he saw, "at Lyons, a sawmill driven with an upright wheel, and the water that makes it go is gathered into a narrow trough, which delivereth the same water to the wheels. This wheel hath a piece of timber put to the axletree end, like the handle of a broch (a hand-organ), and fastened to the end of the saw, that it continually eateth in, and the handle of the same is kept in a rigall of wood from severing. Also the timber lieth, as it were, upon a ladder, which is brought by little and little to the saw by another vice." From this description of the primitive power saw, it would seem that it was probably fast only at one end, and that the broch-handle and rigall performed the part of the arm in the common use of the hand-saw.

It must always have been a very considerable object for men to possess, or obtain, the power of raising water otherwise than by mere manual labor. Yet nothing like the common suction pump has been found among rude nations. It has arrived at its present state only by slow and doubtful steps of improvement; and, indeed, in that present state, however obvious and unattractive, it is still something of an abstruse and refined invention. It is still unknown in parts of Asia, Africa, and the New World, beyond the pale of European settlements, or the reach of European communication. The Greeks and Romans are supposed to have been ignorant of it, in the early times of their history; and it is usually said to have come from Alexandria, where physical science was much cultivated by the Greek school under the patronage of the Ptolemies.

These few and scattered historical notices of important inventions have been introduced only for the purpose of suggesting that there is much which is both curious and instructive in the history of mechanics; and that many things, which to us in our state of knowledge seem so obvious that we should think they would at once force themselves on men's adoption, have, nevertheless, been accomplished slowly and by painful efforts.

But if the history of the progress of the mechanical arts be interesting, still more so, doubtless, would be the exhibition of their present state, and a full display of the extent to which they are now carried. The slightest glance must convince us that mechanical power and mechanical skill, as they are now exhibited in Europe and America, mark an epoch in human history. Machinery is made to perform what has formerly been the toil of human hands, to an extent that astonishes the most sanguine, with a degree of power to which no number of human arms is equal, and with such precision and exactness as almost to suggest the notion of reason and intelligence in the machines themselves. Every natural agent is put relentlessly to the task. The winds work, the waters work, the elasticity of metals works; gravity is solicited into a thousand new forms of action; levers are multiplied upon levers; wheels revolve on the peripheries of other wheels.

A MILLIONAIRE CLERK.

THIS is the plain tale of a young man, working in his father's office daily from nine o'clock in the morning until four o'clock in the afternoon; who associates with the clerks and does his work as though he were one of them, on a salary of $15 a week; who neither smokes nor drinks, and finds no pleasure in the theatre; whose chief enjoyment is church work, and whose favorite recreation is swimming, skating, or a drive in the park. And yet this young man, if he lives, and he is in the best of health now, will some day undoubtedly be the richest man in the world.

He is John D. Rockefeller, Jr., the only son of his multimillionaire father, and probable heir to a fortune so vast that its owner now says that he cannot estimate it within $10,000,000 or $15,000,000. Whether this fortune is $200,000,000, as is estimated, not even Mr. Rockefeller can tell.

In his tastes, his every-day habits, his pleasures, and his beliefs, young Rockefeller

is a most striking contrast to the ordinary son of the millionaire father. In him is proved beyond all doubt the old saying that "blood will tell," for his parents' industry, their religious nature, and love of home are strongely accentuated in him as in them.

Possessed of a fortune that would enable him to gratify any extravagant wish, to pay $500,000 a year for a yacht and think it no waste, to support a racing stable, or to buy a princely estate, he wants none of these. It is to his mind pleasanter to work daily in his father's office, to live quietly at home, and devote his time to religion and charity.

It is not because of lack of opportunity for other things that young John D. Rockefeller, Jr., lives as he does. His position is such that he would be welcomed in society should he wish to attend any of the fashionable functions to which so many people devote their lives. His name and his money would gain him the entrance to houses closed against others not so fortunately situated.

Yet the man wants none of these things, which are the prerogatives of his place. Rather than spend his time thus, he devotes it to the simple enjoyments in which he finds his greatest pleasure, to the quiet evenings at home when he and his father, with their violins, unite in concerts with the young man's sisters, while the mother listens as the sole auditor. The family home, where a life is led as simple as if in a small country village in Ohio, instead of being in the center of the millionaire's district in Fifth Avenue, is at 4 West Fifty-Fourth Street.

During the day the young man works as steadily and faithfully as any of his father's employes, and besides puts his heart to the task, for he is training to manage the vast property that his father has built up. But once away from his desk, the cares of the office are out of his mind, and he looks forward to a pleasant evening at home. The family habits are still affected by the customs they observed in the early days in Ohio.

It is in the church that the young man shows the deepest interest in anything aside from business. He is twenty-seven years old now, but like his father and mother has been since a child a constant attendant at church. Since coming to New York he has become a member of the Baptist Church in Forty-Sixth Street, of which Dr. Faunce is the pastor. There his father for years taught a Bible class and Mrs. Rockefeller now has one. Until recently John D. Rockefeller, Jr., was a member of his mother's class. Since his return from college life at Brown, he himself has had charge of a class of boys, while his sisters for years had their classes.

In a life like this John D. Rockefeller, Jr., finds his pleasure. Aside from his horse, his chief outdoor pleasure is swimming and skating. For the latter a pond has been arranged back of the house, and there, shut off from view from the street, he can enjoy his exercise.

But for a man with present opportunities like his, and a future which seems illimitable in its prospects of wealth, there is no more unique life than that led by young Rockefeller. His work is as regularly done as though he depended on a weekly wage for his support, and his pleasures are as simple as those of a country lad.

THE FITTEST SURVIVE.

YOUNG men on the threshold of life's career must know that they are to be subjected to the law of natural selection. In the great struggle for existence none but the fittest survive. How many among you, young men of today, will emerge unscathed from the terrible ordeal? Will any of you be rolled up as moral wrecks on the sands of time? We would not be prophets of evil, but we impress upon you an adequate conception of the severity of the test through which you must all pass.

Society is a hard master. Your fellow men will sift you as wheat. Some of you are even now fighting an unequal battle with poverty and friendlessness. Others are exposed to the still greater dangers of wealth and ease. All alike must be tried as by fire before the world can decide what manner of men you are.

That you may pass the ordeal in triumph, you must choose your career in life wisely. For this end study your own powers, tastes, and tendencies. Your profession should be the choice of your mature mind, not the whim of boyhood. It must be your own choice, not that of interested and partial friends. Fix your thought upon its drudgeries and annoyances, not alone upon its possible honors and rewards.

When your choice has once been made, it should, except for extraordinary considerations, be final. Like the Spanish adventurer, burn your ships behind you. Cut off all hope of retreat. Put your whole powers into the channel you have marked out. You will never feel the full weight of the disagreeable elements of your profession till you have gone too far to retreat. Remember that almost all the work that strengthens character is drudgery pure and simple.

SUCCESS AND PHYSICAL HEALTH.

THE success of men depends in no slight degree on their physical health, and a public writer has gone so far as to say that "the greatness of our great men is quite as much a bodily affair as a mental one. A healthy breathing apparatus is as indispensable to the successful lawyer or politician as a well-cultured intellect."

The thorough aeration of the blood by free exposure to a large breathing surface in the lungs is necessary to maintain that full vital power on which the vigorous working of the brain in so large a measure depends. The lawyer has to climb the heights of his profession through close and heated courts, and the political leader has to bear the fatigue and excitement of long and anxious debates in a crowded house. Hence, the lawyer in full practice and the parliamentary leader in full work are called upon to display powers of physical endurance and activity even more extraordinary than those of the intellect—such powers as have been exhibited in so remarkable a degree by Brougham, Lyndhurst, and Campbell; by Peel, Graham, and Palmerston—all full-chested men.

Though Sir Walter Scott, when at Edinburgh College, went by the name of "The Greek Blockhead," he was, notwithstanding his lameness, a remarkably healthy youth: he could spear a salmon with the best fisher on the Tweed, and ride a wild horse with any hunter in Yarrow. When devoting himself in after life to literary pursuits, Sir Walter never lost his taste for field sports; but while writing "Waverly" in the morning, he would in the afternoon course hares. Professor Wilson was an athlete, as great at throwing the hammer as in his flights of eloquence and poetry; and Burns, when a youth, was remarkable chiefly for his leaping, putting, and wrestling. Some of our greatest divines were distinguished in their youth for their physical energies. Isaac Barrow, when at the Charterhouse School, was notorious for his pugilistic encounters, in which he got many a bloody nose; Andrew Fuller, when working as a farmer's lad at Soham, was chiefly famous for his skill in boxing; and Adam Clarke, when a boy, was only remarkable for the strength displayed by him in "rolling large stones about"—the secret, possibly, of some of the power which he subsequently displayed in his manhood in rolling forth large thoughts.

While it is necessary, then, in the first place, to secure this solid foundation of physical health, it must also be observed that the cultivation of the habit of mental application is quite indispensable for the education of the student.

DIVERSITY IN EDUCATION.

EVERY youth of eighteen is an infinitely complex organization, the duplicate of which neither does, nor ever will, exist. His inherited traits are different from those of every other human being; his environment has been different from that of every other child; his passions, emotions, hopes, and desires were never before associated in any other creature just as they are in him; and his will force is aroused, stimulated, exerted, and exhausted in ways wholly his own. The infinite variety of form and feature, which we know human bodies to be capable of, presents but a faint image of the vastly deeper diversities of the minds and characters that are lodged in these unlike shells. To discern and take due account of these diversities, no human insight or wisdom is sufficient, unless the spontaneous inclinations, natural preferences, and easiest habitual activities of each individual are given play. It is for the happiness of the individual, and the benefit of society alike, that these mental diversities should be cultivated, not suppressed. The individual enjoys most that intellectual labor for which he is most fit; and society is best served when every man's peculiar skill, faculty, or aptitude is developed and utilized to the highest possible degree. The presumption is, therefore, against uniformity in education, and in favor of diversity at the earliest possible moment.

EDUCATION'S FIRST STAGE.

THE first stage in the education of the true worker is self-consciousness; the final stage is self-forgetfulness. No man can enter the final stage without passing through the initial stage; no man can enter the final stage without leaving the initial stage behind. One must first develop intense self-consciousness, and then must be able to forget and obliterate himself. One must first accept the most exacting discipline of the school, and then must forget that schools exist. The apprentice is the servant of detail; the master is the servant of idea; the first accepts methods as if they were the finalities of art; the second uses them as mere instruments.

STUDENTS WHO HAVE BENEFITED THEMSELVES

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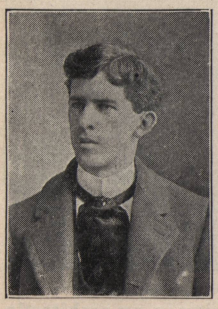
FROM BRICKLAYER TO ARCHITECT.



Before enrolling in the Schools, and while pursuing the study of the Architectural Drawing Course, I was a bricklayer, and worked with my father on the mason work of several large buildings. After completing the Course I held responsible positions in the offices of two of the leading architects of Cleveland, O. I am now successfully practicing architecture, and have recently furnished plans and specifications for the new $8,000 school building that is to be erected at Corry, Pa. My success is due entirely to the Schools.—*Michael A. Crowe (U. 233), Meadville, Pa.*

BECAME A SUCCESSFUL STATIONARY ENGINEER.

It gives me great pleasure to recommend The International Correspondence Schools to any one. They have done for me more than they advertised. When I began the study of the Stationary Engineers' Course I was a locomotive engineer. The completeness and simplicity of the Instruction Papers agreeably surprised me. After completing my Course I accepted the position of chief engineer of the State Hospital for the Insane at Massillon, O. I now have charge of a complete electric light and power plant, water works, and refrigerating plant. It is through the instruction received in my Course that I have been able to obtain and hold this position.—*Clarence E. Sutton (H. 196), Massillon, O.*

FROM OFFICE BOY TO BOOKKEEPER.

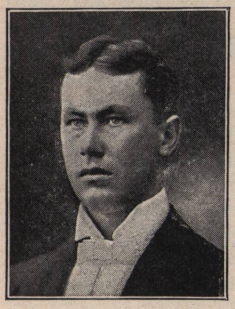
In the latter part of 1896 I went to work for L. Sternberg & Co., Newark, N. J., as office boy. After I had been there about one year, a friend explained to me the methods of The International Correspondence Schools, and as I knew nothing about bookkeeping I enrolled in the Complete Commercial Course.

Since taking the Course, I have been advanced from office boy to assistant bookkeeper, and my salary has been raised three times on account of my knowledge of bookkeeping. I am still at the same work, and hope to rise higher when I have completed double entry. My success is due entirely to the Schools.—*Frank W. Mertz (C. C. 433), Newark, N. J.*

INCREASED HIS SALARY $5.00 PER WEEK.

Before taking the Wiring and Bell-Work Course of The International Correspondence Schools, I was a shoe salesman, at a salary of $8.00 per week. I still hold the same position, but receive $9.00 per week. I have one afternoon and three evenings off duty each week. This spare time I turn to advantage by doing electrical work. In this way I increase my salary $5.00 per week, making $14.00 in all. I now feel qualified to accept a position in an electrical establishment, and when the opportunity occurs, I intend to change my occupation.—*Geo. C. Jackson (J. B. 87), 3960 Market St., Philadelphia, Pa.*

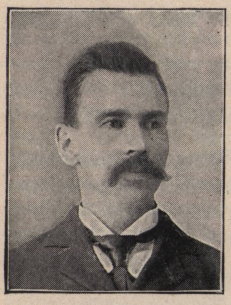
FROM CHAINMAN TO ASSISTANT ENGINEER.



I began work seven years ago, as chainman on an engineering corps. I have advanced in the profession to the position of assistant engineer in the Civil Engineering Department of one of the largest iron companies in this country. My work is varied, covering nearly all branches of the profession.

Without any previous mathematical education, I have been able to keep abreast of the times through the Course I have taken in the Schools. During the time I have been a student in the Bridge Engineering Course, my salary has been nearly doubled.—*Chas. L. Hower (B. 440), Johnstown, Pa.*

FROM MINER TO SCHOOL TEACHER.



I received no education as a boy, and had worked in the mines nearly twenty years when I enrolled in the Complete Coal Mining Course of The International Correspondence Schools. My progress was very satisfactory to me, as I was able to complete the Course in two years. This was largely due to the fact that all letters of inquiry for further information on any problem were very promptly and cheerfully answered. The Course not only fits a man for a mining position, but for anything else to which he may aspire. Through the knowledge gained in the Schools, I have been able to obtain a first-grade teacher's certificate, and am now teaching in the public schools of this place at a salary of $70.00 per month. I owe my present position to the Schools, and my success in teaching to the able reasoning in the Instruction Papers, which treat matters in such logical order that any one who studies can understand them.—*John Graham (C. M. 1189), Rockvale, Col.*

FROM SCHOOL TEACHER TO ARCHITECT.

I have very nearly finished the Complete Architectural Course of The International Correspondence Schools of Scranton, Pa., and wish to state that I consider the Schools the greatest educational institution that has ever been established. My Course has been of almost inestimable value to me, as I am now holding a position which I could not have filled had it not been for the knowledge gained in my Course.

When I enrolled, and while studying the Course, I was a school teacher in Triangle, N. Y. Nearly all my studying has been done after working hours, and I have been to no extra expense to get my education. I am now working in an architect's office, where I do all the estimating and draw all the plans.—*Chas. G. Baker (A. 310), Scranton, Pa.*

FROM LABORER TO COUNTY SURVEYOR.

Prior to the time when I enrolled in The International Correspondence Schools, I had principally followed mining and mechanical labor, as my education was limited to a few years' schooling when I was quite young. I felt that a technical education would enable me to earn higher wages, so enrolled in the Schools. Since completing my Course in Surveying and Mapping and obtaining a diploma, I received the nomination for County Surveyor and Road Supervisor, and was elected by a nice majority. I receive $5.00 per day for road supervising, and $7.00 per day for surveying. I shall always remember with pleasure my work in the Schools, and advise all my friends to enroll and receive the certain benefits of knowledge.—*Chas. F. Donyes (S. M. 90), Philipsburg, Mont.*

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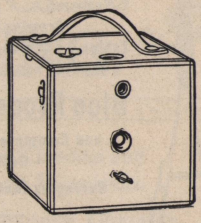

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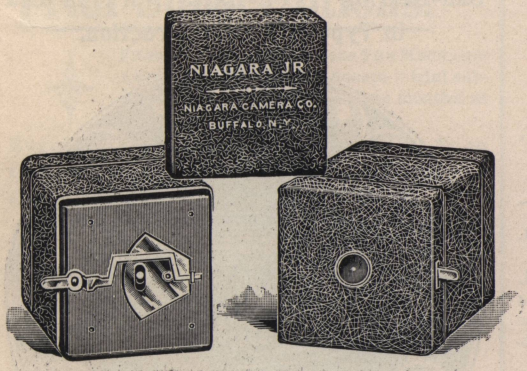

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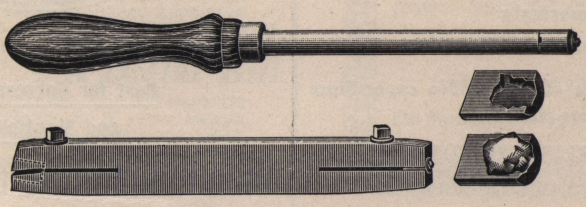

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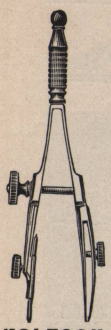

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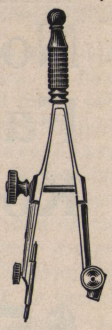

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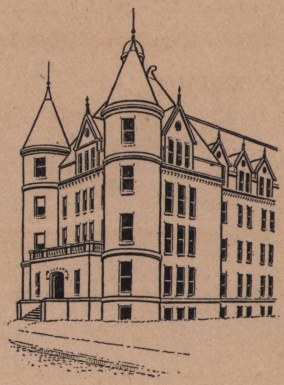

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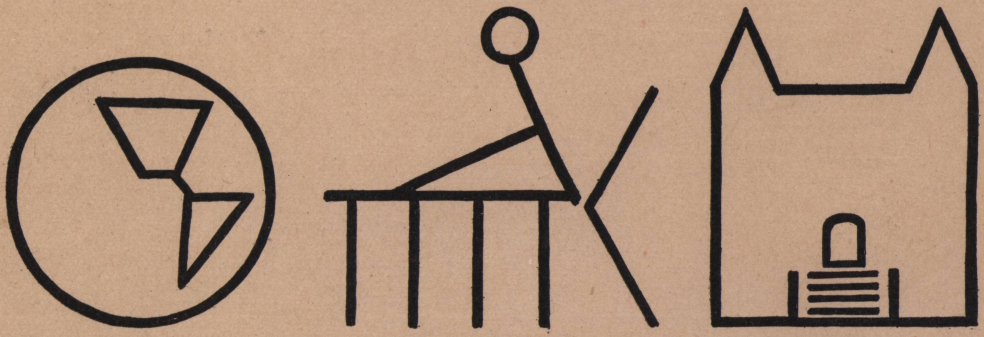

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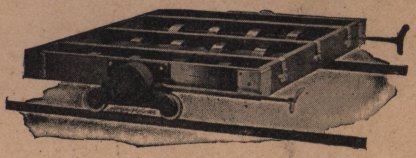

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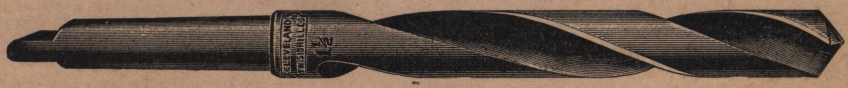

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